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TABLE OF CONTENTS.

ENGINEERING NEWS OF THE WEEK..... 417
The Tidal Marshes of the Bay of Fundy (illustrated).. 418
Electrical Conduits and Cables..... 419
The Water Supply System of the Charleston City Ry. Co. (illustrated)..... 421
Coal Storage Plant of the Tamarack Mining Co., Dollar Bay, Mich. (illustrated)..... 422
Coal Mine Plant at Diamondville, Wyo..... 423
Tests of Combined Concrete and Expanded Metal Floors at Long Island City, N. Y..... 428
Water Storage Tanks Under Air Pressure at Babylon and Southampton, L. I. (illustrated)..... 429
Notes from Recent City Engineers' Reports..... 429
Present Status of the New York Canal Improvements..... 430
Official Statistics of the Railways of the United States in 1896..... 431
A New Year Poem..... 432
The Pollution of the Potomac River..... 432
EDITORIAL NOTES..... 424
Selling American Locomotives to European Railways—Building Locomotives to Specifications in the United States—Problems in Electrical Conduit Construction—The Effect of Alternating Currents on Cable Insulation—Evening Opening of the New House of the American Society of Civil Engineers.
EDITORIAL:
Fog in Tunnels—and Elsewhere..... 425
LETTERS TO THE EDITOR..... 426
A Primitive Cantilever Bridge (illustrated)—Sewage Disposal for a Country House at Branford, Conn. (illustrated)—The Claim for Saving in Fuel by the Hawley Down-Draft Furnace—The Computation of Strains in Coal and Grain Bins.

THE CONTRACT FOR THREE 30,000,000-GALLON pumping engines for the new water supply of Cincinnati has been awarded to the Lane & Bodley Co., of Cincinnati, for $387,000, this price also including the necessary boiler plant. The successful bid includes an offer to build a fourth pump for $119,000. The pumping engines will be self-contained, vertical, triple-expansion, crank and fly-wheel machines. The other bids were given in our issue of Dec. 16. It is reported that the Lake Erie Engineering Co., who, on the face of the figures, were the lowest bidders by some $10,000, for the kind of pump covered by the award, will contest the award.

THE PNEUMATIC DISPATCH SYSTEM now in use in New York and Boston will probably be adopted in Chicago in the near future. The present plan is to run 8-in. pipes to six different railway stations and to all postal substations, using the alleys, which method will not interfere with street traffic.

A COMPREHENSIVE TUBULAR DISPATCH SYSTEM for Brooklyn, N. Y., is being talked of. This contemplates tubes running from Coney Island, Rockaway Beach, Jamaica, Bensonhurst, Flushing, Flatbush, East New York and other places to the post office in Brooklyn. It is even suggested that a station be located on the Narrows, opposite Quarantine, from which all incoming first-class matter could be sent at once to the Brooklyn post office. It is hoped to have the tube across the Brooklyn Bridge in operation inside of 30 days.

THE FORMAL OPENING OF THE PNEUMATIC postal system in Boston, Mass., occurred Dec. 17 in the post office building of that city. This system, like the one in New York, uses the apparatus covered by the Batcheller patents. The tube is 8 ins. in diameter and about five-sixths of a mile in length. The system is owned and operated by a local company, which took the contract to transmit the mails between the post office and the Union Station. The consideration is $18,000 per year, of which amount between $5,000 and $6,000 is returned to the government in the form of rent for steam to operate the machinery.

THE NEW YORK AQUEDUCT CLAIMS of O'Brien & Clark and Brown, Howard & Co., long in controversy, were settled on Dec. 28 by an offer by the city of $700,000 in full for all claims arising out of the construction of the first nine sections of the new Croton Aqueduct. The offer was accepted by the legal representatives of the contractors, as follows: Walston H. Brown, receiver for Brown, Howard & Co., will receive the sums of $133,670.40, $134,114, $87,528 and $79,689.10; O'Brien & Clark will receive $264,000. The Corporation Counsel, in giving his reasons for this compromise, said that many of the witnesses upon whom the city would have to rely, in further trials, had either left the vicinity or were dead. He deemed it inevitable that a commission would some time examine the claims and make the contractors an award, and he believed that, under present conditions, these awards would exceed the amounts upon which a settlement had now been made. The total amount of claims involved exceeded $10,000,000. The claims arising from the building of Sections 10, 11 and 12 have not been settled. The advent of a Greater New York and the incidental house cleaning preparatory thereto, probably has something to do with this long deferred settlement.

AN EIGHT-TRACK DRAWBRIDGE is to be built over the Chicago drainage canal, near Campbell Ave., to carry the tracks of the Pittsburg, Cincinnati, Chicago & St. Louis Ry., Chicago & Northern Pacific R. R. and the Union Stock Yards & Transit Co. The plans prepared by the bridge department of the Sanitary District are for a bridge with four through trusses, two tracks being between each pair of trusses and one track outside each outer truss. This structure will be about 400 ft. long and 160 ft. wide. Bids for this bridge were opened by the Board of Trustees of the Sanitary District of Chicago on Dec. 22, as well as bids for special designs. Three special designs were submitted, the bids being for the bridge with and without the operating machinery. All the regular bids were exclusive of operating machinery. For the substructure, ten bids were submitted, the lowest being that of the Lydon & Drews Co., of Chicago, $92,454. The totals of the bids for the superstructure are given below, and the itemized bids for this and two other bridges will be found in our news columns:

Bids on Engineers' Plans.

King Bridge Co., Cleveland, O.	$225,000
Edge Moor Bridge Works, Wilmington, Del.	230,000
Elmira Bridge Co., Elmira, N. Y.	224,000
Carnegie Steel Co., Pittsburg, Pa.	249,550
American Bridge Works, Chicago.	260,700
Pennsylvania Steel Co., Steelton, Pa.	261,408
New Jersey Steel & Iron Co., Trenton, N. J.	262,424
J. G. Wagner Co., Milwaukee, Wis.	262,800
Detroit Bridge & Iron Co., Detroit, Mich.	265,784

Bids on Special Plans.

Edge Moor Bridge Works, Wilmington, Del.	184,000
Extra for operating machinery	75,000
Scherzer Rolling Lift Bridge Co., Chicago.	235,000
Extra for operating machinery	105,000
C. L. Strobel, Chicago.	254,000
Extra for operating machinery	93,000

CIVIL SERVICE EXAMINATIONS must be taken by the candidates for a number of important positions under Chicago's municipal government, according to a recent decision of the Supreme Court of Illinois. The positions involved, with their salaries, are below, and it is said that examinations will soon be held:

City engineer.	$4,500
Assistant city engineer.	2,250
Engineer of bridges.	1,800
City architect.	1,500
Superintendent of streets.	3,600
Chief sidewalk inspector.	1,500
Nine sidewalk inspectors.	900
Eight obstruction inspectors.	900
Nineteen district street foremen.	1,500
Thirty-four ward inspectors.	1,000
Superintendent of maps.	800
Secretary department of public works.	2,500
Chief janitor city hall.	1,350
Superintendent of sewers.	3,600
Superintendent of water office.	3,650
Water assessor.	2,000
Chief water inspector.	1,350
Superintendent meter department.	1,500
Chief clerk and bookkeeper water office.	1,500
Superintendent leak and waste department.	1,350
City electrician.	4,500
Secretary health department.	1,500
City chemist.	1,500
Chief meat inspector.	1,000
Chief smoke inspector.	2,000
Private secretary to chief of police.	1,800

CONCRETE SEWERS are proposed for the two intercepting sewers, 16 and 20 ft. diameter, which are to carry the sewage of Chicago to the drainage canal. The aldermen are said to fear a rise in the price of brick, and the council has passed a resolution appointing a committee to visit Reading, Pa., and inspect the concrete sewers at that place. The committee is to consist of the mayor, commissioner of public works, city engineer, superintendent of sewers, and four aldermen.

AN INTERNATIONAL HEALTH EXPOSITION is to be held in New York city, at the Industrial Building, April 25 to May 31, 1898. There will be exhibits relating to domestic and municipal sanitation, foods, industrial hygiene, heating and ventilation, fire protection, preventive medicine, the literature of sanitation and a variety of other things. There will also be lectures on some of these subjects. Mr. Chas. F. Wingate is the Supervising Director and Mr. B. E. Greene the Secretary of the Exposition. Either of these gentlemen may be addressed as above. There are 15 advisory committees with an aggregate membership of 92 persons, men and women. The Committee on Sanitation has six ministers, but not a single engineer on its membership list. There is a separate committee on "Sewerage of Cities," consisting of two members, Messrs. Rudolph Hering, M. Am. Soc. C. E., and Geo. H. Frost, Assoc. Am. Soc. C. E. The Committee on "Ventilation and Heating" is headed by Prof. S. H. Woodbridge, of the Massachusetts Institute of Technology, and Prof. Henry Morton, of Stevens Institute.

THE ELECTRICAL EXPOSITION to be held at Madison Square Garden, New York city, May, 1898, bids fair to surpass the similar exposition held at the Grand Central Palace two years ago. The company engineering the scheme has at its disposal some 35,000 sq. ft. of floor space. The basement will be devoted to operative exhibits, such as engines, dynamos, motors, etc.

THE FIRE AT LAFAYETTE COLLEGE completely wrecked the fairly well equipped testing laboratory. As a result the civil engineering department, while for the present crippled, will either have a separate new building or considerable more space. It is hoped to have everything in running order again by September next.

FIRE DESTROYED THE CHICAGO COLISEUM early on the evening of Dec. 24. This structure was built in 1895 and was notable for its great size, being 675 ft. long and 300 ft. wide, with its main auditorium covered by eleven steel roof arches having spans of 215 ft. Its capacity was 50,000 persons and in it was held the National Democratic Convention of 1896, in which William J. Bryan was nominated for President. It was for assemblies of this character and for exhibitions, football games, bicycle races and similar purposes that the building was erected. Its location was on 63d St., near Stoney Island Ave., practically on the site of the "Wild West Show," which was so familiar an adjunct of the Columbian Exposition of 1893. The side walls of the building were of brick and served simply to inclose the building, all the weight of the roof being carried by the steel arches. The roof covering, galleries, floors, seats and all interior fittings were of wood. No partitions intersected the main auditorium, which was also open clear to the roof. All the woodwork was of the lightest and flimsiest construction, and would burn like tinder. Full details of the steel work were published in our issue of Nov. 12, 1896.

At the time of the fire a sort of winter carnival was being held in the building and the auditorium and galleries were occupied with booths made of bunting and light wooden framework. An explosion of gasoline in one of these booths started the fire, which spread so rapidly that the few hundred people in the building barely escaped with their lives. In 15 minutes from the time the fire started the building was in ruins. Early press reports stated that five lives were lost in the fire, but later despatches do not confirm these figures.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Norfolk & Western Ry. Dec. 24, four miles west of Pulaski, Va. An east-bound passenger train and a freight collided, killing a postal clerk and injuring two employees. The accident is supposed to have resulted from a mistake on the part of the engineer of the passenger train.

AN EXPLOSION OF ACETYLENE GAS in the works of the United States Acetylene Liquefaction Co., Jersey City, N. J., killed two men and injured several others. Fortunately the works are isolated or a serious loss of life would have resulted. According to reports, there was a series of explosions at intervals varying from a half to four minutes, and as there were 10 tanks in the works, this is quite probable.

THE EAST RIVER FRONT IMPROVEMENT, proposed by the board of consulting engineers, made up of Mr. George S. Morison, Prof. Wm. H. Burr and Gen. Wm. P. Craighill, is described as follows, so far as the marginal way is concerned: This way would be 200 ft. wide along the bulkhead north to Jackson St. From this point two car tracks pass along Jackson St. to a subway which ends at Lewis and Third Sts. From the latter point the marginal way is 140 ft. wide to 8th St. Along the easterly side of the marginal way will be four railway tracks which may be connected by switches with the river front and the adjoining property. Above 8th St. this 140-ft. marginal way, with its tracks, may be so extended, as far as E. 23d St., as to leave a space 500 ft. wide between it and the bulkhead; this space to be occupied by warehouses. The present Dock Board favors the plan; but no action was taken at the late meeting, owing to the fact that the official life of the board ends on Jan. 1.

THE NEW YORK STATE RAILWAY COMMISSION has granted the application of steam railways of the state for an extension of time in which to complete the equipment of freight cars with automatic couplers. The law provides that this equipment should be completed by Jan. 1, 1898; an extension of two years from that date is granted. No action was taken on the further request of some of the roads that they be exempted from the New York state law of 1893, compelling them to annually equip 10% of freight cars with automatic air-brakes. After Jan. 1, 1898, the commission will consider special cases of proposed exemption, when application is made and reasons stated. The United States safety appliance law only demands that a sufficient number of freight cars in each train shall be equipped with brakes to enable the engineer to control the train from the engine; and the New York State Commission may, after investigation, ask for an amendment of the law of 1893, to embody the same requirement.

THE EXTENT OF AMERICAN EXPORTS is well shown by a paragraph in a recent issue of the "American Machinist," which says:

On a trolley line in Birmingham, England, the rails are made in Pittsburg, the cars in Philadelphia, the boilers in Erie, the engines in Milwaukee, and the electric fittings in Schenectady.

THE TIDAL MARSHES OF THE BAY OF FUNDY.

By William B. Mackenzie, M. Am. Soc. C. E.*

Between the Bay of Fundy and the Strait of Northumberland lies a strip of low land 15 miles wide, over which, in a straight line, stretches the ambitious, but still unfinished, Chignecto ship railway. During the post-tertiary submergence this part of the country was 220 ft. below its present level, and the Champlain or Leda clay and the Saxicava sands were being deposited on the sea bottom. Tides of the ordinary height, 10 to 15 ft., perhaps, swept across into Northumberland Bay; the bold cliffs and headlands of the coast showing that erosion was great and extensive. Floating ice was carried in both directions and has left its deep groovings on the bordering shores.

Several shore terraces, now standing high above the sea, tell us plainly that the land rose, not evenly and gradually, but spasmodically. When the "divide" appeared above the troubled waters, the isthmus of Chignecto was born, and the eastern part was no longer an island. The tidal wave was then thrown back upon itself, and while recovering from the shock lost part of its load of sediment. Since then, all down through the ages, have the recurring tides been depositing this material and filling up the valleys and fresh water streams flowing into the Bay of Fundy. In some such fashion have been formed those great prairie-like salt marshes which now constitute much of the agricultural wealth of New Brunswick and Nova Scotia.

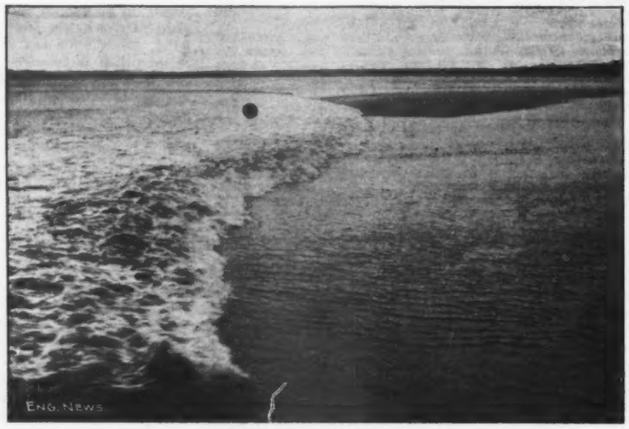

FIG. 1.—THE "BORE" OR TIDAL WAVE IN THE PETITCODIAC RIVER AT MONCTON, NEW BRUNSWICK.

Height: 5 ft., 4 ins.

The tidal wave, originating in the Southern seas, is here thrown against the funnel-shaped bay, and, following the rising grade of its bed (4 ft. per mile) the waters are heaped up from 22 to 53 ft. and rush up several of the rivers in the form of "bores," 5 to 6 ft. high, at the rate of six to ten miles per hour. The "bore" of the Petitcodiac River at the city of Moncton, New Brunswick, is shown in the accompanying view, Fig. 1, which is reproduced from a photograph. The range of the Saxby tide on Oct. 5, 1869, was 57½ ft.

The dynamic power of the tidal water is so great that, at the inner extremities of the bay, it is forced up 16 ft. above, and at ebb tide runs out to 20 ft. below the normal ocean level. The tidal water carries a heavy load of sediment, eroded from the soft carboniferous reddish-gray shales which form the shores of the bay, and this sediment is deposited wherever the tidal water reaches. All the salt-dyked marsh bordering on the bay has been formed in this way. The material is a finely-divided red oxidized sediment, the deposits varying from twelve-thousandths of an inch to over one inch at every tide. A single sample of water taken from the Petitcodiac River at Moncton, New Brunswick, when the tide was at half flood, showed the proportion of sediment to water, by weight, to be .0037, or five times the amount of sediment carried by the Mississippi at Columbus, Ky. Any peat, mossy, corky marsh, lying below extreme high water can be made fertile by draining and allowing the tide to overflow it and deposit sediment for a few years. Salt marshes are highest next the estuaries because the largest and heaviest particles are deposited first. Toward the foot of the upland the marshes are lower and softer and the cross dykes usually sink here more than elsewhere. Salt marshes formed of sediment deposited in sea-water do not sink or subside when dyked and drained. Peaty marshes in New Jersey, U. S., sink from 1 ft. to 4¾ ft. when drained. Fresh water peat bogs in Nova Scotia usually contain from 90 to 95% of water by weight. I have known these peat bogs, when drained, 5 or 6 ft. deep, to carry a railway with scarcely any subsidence, the partly decayed fibrous peat making an elastic and perfect road-bed, after the water had evaporated or run into the side ditches. Fresh-water peat bogs near Sackville, New Brunswick, when flooded by the tide and covered with sediment from 6 ins. to 3 ft., sank from 1 to 4 ft. A salt marsh at Island light, Suffolk Co., N. Y., having a depth of from 1½ to 9½ ft., sank 11% to 27½% of its original depth in one year, under sand and earth filling 3 ft. thick. The upper surface was tough and leathery sod and the mud underneath was composed of seaweed and vegetable matter soft and compressible. The tide rose to within 6 ins. of the original surface. The "Engineering Record" of June 6, 1891, says "peat bogs containing 90% of water and 10% vegetable matter, when drained, will be reduced in height one-third."

It will be seen by the positions of the peat bogs shown in the accompanying sections, Fig. 2, that a subsidence of these tidal deposits of the Bay of Fundy has taken place in some comparatively recent period, and that it has varied from 5 to 80 ft. As far as can be judged, however, from the oldest existing dykes, no settlement has taken place in the last 200 years.

The salt marshes at Amherst, Sackville and Dorchester, in New Brunswick, have not extended seaward to any great extent since they were first dyked, 200 years ago, but the estuaries are slowly filling up and becoming narrow. At Onslow, near Truro, in Nova Scotia, marshes have been made by building spurs or groynes of brush and stone at certain distances apart along the shore. Sediment is deposited in the still water between the spurs, and in time a new dyke is constructed outside the old one. In places, three or four dykes may now be seen, one outside the other, and from 50 to 300 ft. apart.

The red sediment of these marshes has changed to gray by the chemical alteration of the iron oxides into sulphides by the sea-water, so that the deposit is now bluish-gray below and red where overflown. Cultivation and drainage changes the blue to red again. When dykes are good and the marsh well drained, the soil is almost as dry as upland and very fertile. Hay has been grown for more than 150 years without manure. Grains of all kinds grow well, but upland is preferred for root crops. Some of the older marshes have become impoverished and have turned into blue marsh—a wet, spongy, fetid formation, quite unproductive; but, a few years since, it was discovered that to make them again fertile, all that was necessary was to open the dykes and flood the marsh for a year, or until a sufficient thickness of sediment was deposited. This causes a loss of the hay crop for three or four years. Later still it has been found that by opening the dykes in winter, for two or three seasons, enough material is deposited to fertilize the soil without destroying the hay crop. The first year after heavy flooding, Spartina stricta, commonly called broad-leaf, cord-grass, marsh-grass, sedge-grass, creek-sedge, thatch-grass, etc., grows in patches; the next year it covers a larger area and increases until, in time, it gives place to English hay (Phleum pratense), which increases as the salt is washed out of the soil by atmospheric action and the upper strata are aerated.

The grasses seem to appear first after flooding in about the following order: Sand-fire, Goose-tongue, Lamb's quarters (Chenopodium album), Broad-leaf (Spartina stricta), Indian turnip, Couch-grass (Agropyrum repens), English hay (Phleum pratense), Fox-tail (Setaria glauca), Brown-top, Black-grass (Juncus gerardi). The following analyses, taken from the 1889 report of the Connecticut Agricultural Experimental Station, will give an idea of the comparative value of some of the different grasses:

Common name.	Water.	Ash.	Fat.	Nitrogen-free extract.	Crude fiber.	Albuminoids.
Broad-leaf[1] grass..	....	11.70	2.20	49.5	29.40	7.20
Couch grass[2]	7.00	6.93	1.93	41.9	33.02	9.22
English hay[3]	....	5.50	2.30	50.4	34.40	7.40
Meadow grasses ..	8.04	5.13	....	....	27.25	5.88
Black grass[4]	....	7.9	2.60	51.3	29.00	9.20

Scientific name: [1]Spartina stricta. [2]Agropyrum repens. [3]Phleum pratense. [4]Juncus gerardi.

In New Brunswick there are 34,000 sq. acres of this tidal marsh, and in Nova Scotia 43,000 sq. acres, almost all in good condition. The English hay, when cut, will sell for $8 per ton, or about $7 standing, and the yield is 2 to 2½ tons per acre. The value is from $75 to $180 per acre for marsh growing English hay, and about half as much for marsh growing broad-leaf. The latter is cut about Sept. 1, and is allowed to stand ten days before being stacked or stored in barns. It grows with a narrow, spike-like head, and many long spreading, shiny leaves of a pale green color. It forms a very considerable element of the marsh hay and is excellent food for cattle. The season of bloom is the best time to cut the marsh grasses; when delayed too long much of the nutritive quality is lost.

Drainage ditches in tidal marshes should be of such extent that water can never rise in them above 12 to 20 ins. below the surface of hay marsh, and 20 to 36 ins. in grain marsh. The annual precipitation here is about 70 ins., and in winters when the snowfall is light, the hay roots are considerably winter-killed by the successive freezing and thawing.

When it becomes desirable to carry a dyke across a stream, an "aboideau" is built. The waterway is a wooden sluice closed by a clapper hinged at the top. The pressure of the rising tide closes it, and when the tide falls the pressure of the imprisoned fresh water forces it open. The most important part is the bank around and above the sluice. These banks are built by expert "aboideau" builders, who use brush, poles and clay in alternate layers. The brush consists of spruce and fir bushes, 12 to 20 ft. long, and from 1 to 3 ins. diameter at the butt. A layer of these is placed butts outward. Poles 3 or 4 ins. in diameter are laid across, 5 ft. apart, as binders. The poles are staked, and occasional long stakes are driven to pin the whole together. Sometimes the outer butts are spiked to an extra binder on the outside. About 6 ins. of clay is then put on, then another layer of brush and binders, and so on. The front batter is usually 1 on 1; but is often nearly vertical. Banks made in this way are watertight and will resist wash and scour better than many more costly constructions.

Dykes are usually built about 5 ft. high, 12 ft. wide at the bottom and 3 ft. at top, faced with blue-marsh sods 6 ins. thick, 9 ins. by 12 ins., turned grass side out, the centre of the dyke being filled with blue-marsh mud well packed. English-marsh sods are not used for dykes because the soil is too friable and there are not sufficient roots to knit the mass together. The material is taken from a ditch dug a few feet inside the dyke. At Moncton, New Brunswick, the general level of the marsh surface is 1 to 2 ft. below high water of ordinary spring tides, and the crest of the dyke is 2 ft. above the same plane.

Broad-leaf marsh is never plowed; it is only when English hay makes its appearance that it is known to be in a fit condition for plowing. A question is "How does the English hay get in?"

* Chief Engineer, Intercolonial Ry., Moncton, N. B.

From seed carried by the wind, probably. English hayseed is often sown and harrowed in to hasten the process; but even if this is not done, it will, in time, take possession of the soil.

Within the last 50 years, Indian canoes have floated over the stagnant headwaters of the Missiquash River, to within three miles of the water of Northumberland Strait; the watershed being but 2½ miles broad and its crown but 13 ft. above high water in the Bay of Fundy.

A company of five persons (two residents of Boston and three Canadians) are now engaged in digging a canal parallel to the head water of the Missiquash. The canal will be six miles long, 15 ft. deep, 60 ft. wide at the top, and 6 ft. wide at the bottom. The material excavated by the steam shovel will form dykes on both sides. By this canal 5,000 sq. acres of useless swamp or indifferent marsh, costing 50 cts. to $15 per acre, will be reclaimed and will sell for $50 to $100 per acre. The

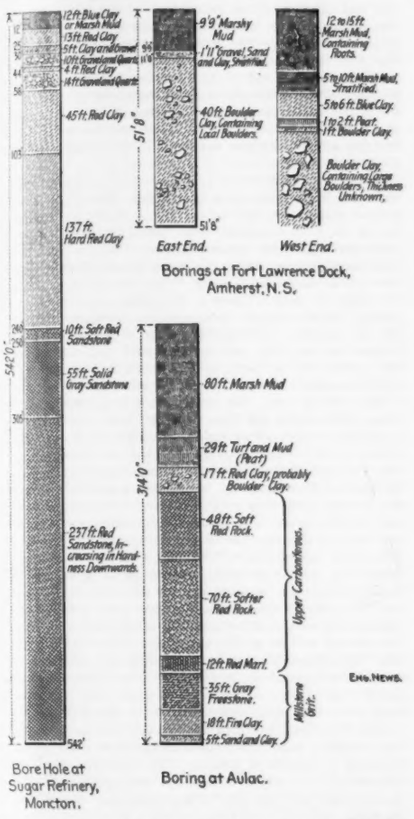
12 ft. Blue Clay or Marsh Mud
13 ft. Red Clay
5 ft. Clay and Gravel
10 ft. Gravel and Quartz
4 ft. Red Clay
14 ft. Gravel and Quartz
45 ft. Red Clay
137 ft. Hard Red Clay
9'9" Marshy Mud
1'11" Gravel, Sand and Clay, Stratified.
40 ft. Boulder Clay, Containing Local Boulders.
51'8"
East End.
12 to 15 ft. Marsh Mud, Containing Roots.
5 to 10 ft. Marsh Mud, Stratified.
5 to 6 ft. Blue Clay.
1 to 2 ft. Peat.
1 ft. Boulder Clay.
Boulder Clay, Containing Large Boulders, Thickness Unknown.
West End.
Borings at Fort Lawrence Dock, Amherst, N.S.
10 ft. Soft Red Sandstone
55 ft. Solid Gray Sandstone
542'0"
237 ft. Red Sandstone, Increasing in Hardness Downwards.
542'
Bore Hole at Sugar Refinery, Moncton.
80 ft. Marsh Mud
29 ft. Turf and Mud (Peat)
17 ft. Red Clay, probably Boulder Clay.
314'0"
48 ft. Soft Red Rock.
70 ft. Softer Red Rock.
Upper Carboniferous.
12 ft. Red Marl.
35 ft. Gray Freestone.
18 ft. Fire Clay.
5 ft. Sand and Clay.
Millstone Grit.
ENG. NEWS.
Boring at Aulac.

Fig. 2.—Sections of Borings Made in the Tidal Marshes of the Bay of Funday.

canal, with dykes and aboideaux, is estimated to cost $60,000. The stagnant ponds at the head of the river will be drained into the canal.

Analyses of the marsh soil and the tidal deposits are as follows (see "Experimental Farm Reports for 1890 and 1891"):

Analyses of Soils from the Dyked Marsh near Sackville, New Brunswick, Canada.

	Sample No. 1.	Sample No. 2.
Water	8.51	14.08
Organic matter	5.34	4.73
Oxide of iron and alumina	10.13	9.82
Clay and sand	74.34	69.60
Lime	.12	.14
Magnesia	.33	.70
Potash	.15	.05
Soluble silica	.30	.15
Phosphoric acid	.15	.17
Carbonic acid, etc.	.63	.56
Total	100.00	100.00
Nitrogen	.12	.14
Clay	63.30	65.46
Sand	11.04	4.14

Analysis of the Salt Mud as Deposited by the Bay of Fundy Tide at Five Islands, Nova Scotia, After Being Air-Dried.

Water	2.850
Nitrogen	.079
Organic and volatile matter	5.230
Sand and clay	76.730
Mineral matter soluble in acid	15.190
Total	100.079
Pounds of nitrogen in 1 ton of air-dried material	1.00

ELECTRICAL CONDUITS AND CABLES.*

By Alex. Dow, M. Am. Inst. Elec. E., Member Detroit Engineering Society.**

A conduit may be defined as a passage or subway for containing electric wires, underground cables, or the like. In a more limited sense, a conduit is a tube or channel into which such conductors may be placed or drawn, but which is not itself accessible for inspection or repair of the conductors, as distinguished from a subway, into which access can be had at any portion of its course.

An instance of a conduit in the narrower sense is a tube, having manholes at different points along its length, the conductors being pulled into the tubes by ropes passing from one mannole to the other; while an instance of a subway would be a tunnel of dimensions to admit of the free passage of men and of the use of tools for any of the common operations required on the conductors. The former construction is common through the United States; the latter is exceptional, the only city where any systematic subway work has yet been completed being St. Paul, Minn., where local conditions make a tunnel construction less expensive than a conduit of any but the smallest capacity.

The history of conduits begins along with the practical use of electric telegraphs. The plans of Professor Morse included a lead pipe conduit into which an insulated wire was to be drawn, and this construction was begun on the experimental Washington-Baltimore line, but failed almost at once through mechanical defects. Wires, strung on posts, were substituted, and were used without protest in the largest American cities, as well as along railroads and highways, until within the last few years. But on the other side of the Atlantic the public objection to the obstruction and disfigurement of the streets by posts and wires was strong enough to force a different solution of the problem, and the opportune discovery of the qualities of gutta-percha as an insulator for electric conductors presented the means; so that the first city telegraph office in London was connected to the railroad telegraph wires by gutta-percha insulated wires drawn into iron pipe, a combination which is standard for telegraphic work in Great Britain till to-day, the pipes being invariably cast-iron and the wire being sometimes, for mechanical reasons, insulated with india-rubber instead of gutta-percha.

It was very much later before the American telegraph companies were obliged to place any of their wires under ground, and the experience of British and European telegraph departments was then available to guide them. Gutta-percha insulated wires were imported, and at least one factory for the making of such wires was established here; but by this time the manufacture of india-rubber had been developed to such an extent in the United States that cables insulated with this latter material could be produced cheaper than those of gutta-percha, and so became standard, as far as anything (with one notable exception) ever has become standard in American cable practice.

The introduction of electric lighting, twenty years ago, brought with it a new set of conditions. The amount of power to be carried by an electric lighting conductor was infinitely greater than that on any telegraph wire. The heating effects of large currents, which were entirely unknown in telegraph practice, had to be considered; and the fact that electrical supply had to be furnished to a large proportion of the buildings in a city introduced problems as to connections and branches which were radically different from anything found in telegraphic work. It is evident that a system of telegraph cables to connect with four or five, or possibly a score of offices, in one city, was a very different thing from a system of electric lighting cables to connect with several thousand different customers. This last condition was at first much the most difficult to meet, because neither the stress due to high electric potential nor the heating due to large currents was, in the earliest electric lighting, much beyond the limits which had been reached in telegraphic work; indeed, in England, some early distributions of electric light were made with entire success through conductors insulated with vulcanized india-rubber, after the same specification as conductors for telegraph purposes. In these instances the pressure was not in excess of 100 volts.

The development of cables and conduits in British practice has been mainly on the line of telegraphic work, and even in this present year electric lighting plants are being insulated in Britain in which the cast-iron pipes forming the conduits have been furnished under specifications identical with those used by the British post office for pipes for telegraph purposes, and the rubber-insulated cables differ only from the wires furnished to the post office in having greater cross-section of conductor and increased thickness of the rubber walls.

But in the United States the public had been educated into the toleration of overhead wires, and our cities were disfigured within five years with a forest of posts and a network of aerial conductors more extensive and more offensive than all the telegraph wires strung in the preceding forty years. Only one electrical inventor, Mr. Edison, spared the time to design a complete system of buried conductors for electric lighting currents, and only the Edison lighting companies were willing, under his advice, to meet the expense of laying down complete underground distributions. The system Mr. Edison designed fulfilled admirably the requirements I have just stated, and, most admirably of all, that of permitting, without interruption of current or weakening of insulation, the frequent connections of service wires for customers. How much this design was in advance of current practice is shown by the record in this city, where the Edison mains, laid in 1886, have remained in continuous service till to-day, while no other electrical supply company has yet constructed an effective system of underground mains, and the city's underground mains for street lighting were only put in service last year. In the lighting department are to be found the greatest variety of conduit and cable constructions and the most complete absence of a standard practice. Even the Edison companies in these latter days have followed strange prophets. Very false prophets, too, have some of them been.

The telephone followed closely on the electric light in its early development, and it also had its period of overhead wires and street obstruction and disfigurement. It has, however, redeemed itself early in the day, and the gigantic poles, carrying hundreds of telephone wires, have disappeared from the business districts of all our large cities. Telephone practice in cables and conduits was at first a copy of the existing telegraph practice, but the scientific study of the telephone carried on under the auspices of the Bell Telephone Co. has led to a differentiation in the direction of the use of cables better suited electrically to telephonic currents of small volume and of very high frequency, and better suited mechanically to the conditions which require many thousands of independent conductors to be concentrated within the smallest possible area in the conduits leading to a modern telephone exchange. This is the notable instance of standardization to which I have previously referred. The modern telephone cable, called the "conference cable," represents the practical experience, the laboratory experiments, and the mathematical calculations of as competent a corps of engineers as can be found in the United States to-day.

To give a history of all the developments of my subject is a task that is far beyond the limitations of a paper like this. The best that can be done is to describe the practice of the present day and to state shortly the reasons of this practice.

Conduits for all systems of electric distributions are governed alike by some conditions. They must, in common with all underground structures, be of material that will not decay in the presence of moisture and of the various destructive agents found in the soil. Among these destructive agents are included the illuminating gas with which the subsoil of most of our cities is saturated, the leakage from sewers and cesspools, and the electrolytic action of the return currents of the street railway system. Further, the conduit must resist the settling of the soil and the bad usage by careless laborers which accompany the frequent excavations made in city streets. Lastly, it must be intersected at convenient points by distributing chambers, commonly called manholes. In addition to these absolute requirements, the conduit should preferably be drained and ventilated, so that there will not be in it any accumulation of water or gas to interfere with the operations of workmen having business with the cables. In a system designed to be water and air tight these latter requirements are not necessary, so that I have indicated them as desirable rather than absolute conditions. You will notice that I say "water tight and air tight." It has been frequently assumed by inventors, and occasionally by skilled constructors of conduits, that a conduit might be made water tight without being absolutely air tight. I am satisfied that if the former condition is sought, both must be secured, because air carries with it a certain amount of moisture and will, on a reduction of temperature, deposit that moisture on any hygroscopic surface with which it is in contact. In my experience I have never seen a water tight or so-called "weather tight" construction, not also air tight, which did not sweat very badly, and even sealed junction boxes and switch boxes, which are only occasionally opened to the atmosphere, will be found to suffer to a slight extent from the same trouble.

It is in order here to discuss the differences between the two classes of conduits—those which are intentionally made air and water tight, and the much larger class, in which there is no special endeavor made to secure tightness. The first class is usually an insulated conduit—that is to say, the conduit construction is itself of insulating material and the conductors are either bare or only covered for mechanical reasons. The insulated conduit has been a dream of hundreds of electricians, and has been sought for persistently from the earliest days of the telegraph. I believe that but two systems have yet been developed which have stood the test of time and can now be classed as successes. The first of these is much in use in England and to some extent on the continent. It is not the production of any one inventor, and although many of

**General Manager, Edison Illuminating Co., Detroit, Mich.

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its details, as used in different installations, are covered by patents, the method as a whole is open to any user and details of a practicable kind can be designed by any good engineer. It is generally known as the "Crompton" system. A conduit, usually of concrete, but sometimes of brick or iron, is constructed in lengths as long as convenient, subject to the limitation that each length must be straight in both the horizontal and the vertical plane. In this conduit are placed porcelain insulators of a saddle or tube shape, over or through which are drawn copper rods or strips. At each change of direction, and at intervals in any straight run of exceptional length, small vaults are built, having air-tight covers, and in these vaults clamps to grasp firmly each conductor are placed, and a screw and nut or equivalent device attached to each clamp wherewith to strain the conductor, so that it does not sag between insulators. In some instances automatic devices are used for taking up any slack due to heating of the conductors, but the more common practice is to apply sufficient initial tension to prevent the copper sagging to a dangerous extent under the maximum heating that is to be allowed.

I do not know that this method has ever been applied to conductors having a potential difference greater than 500 volts. Its continued use proves that it must be a success, but it has developed some characteristic faults. First, there is the sweating, which I have already mentioned. The air trapped in the conduit will, on a fall of temperature, deposit its moisture on the porcelain insulators, and the wooden blocks on which these insulators have been mounted are found in time to become saturated with water. This produces a state of permanent dampness in the conduit, causing a slight general leakage of current, and if the trouble stops at this there is little fault to find, as in the low-tension system such a leakage is not very expensive.

But the gases which saturate the soil also find entrance to the conduit, and the distilled water of condensation absorbs these gases, so that the leakage is aggravated by the change from aqua pura to an aqueous solution of one or more objectionable chemicals, and surface leakages of large quantity become normal, with electrolytic deposition of copper salts on the porcelain. It was believed at one time that the porcelain surface was permanent, but now one user of this system is seriously considering the abandonment of it entirely, because of the impossibility of cleaning or replacing the porcelains as frequently as is required, and because the compounds electrolytically formed are held to have been responsible for explosions of the mixture of air and gas in the conduit.

The other system which has proved a success is one developed by a Detroit inventor, Mr. Cummings. He placed on the market some four years ago tubes into which bare copper conductors could be drawn readily, in lengths up to 300 or 400 feet, and of sizes up to 1 sq. of cross section. To about 1-6 of a square inch these conductors may be round copper rod, the size known as 0000 Brown & Sharp gage being frequently used. Above that cross-section the conductor must be stranded. The tubes are made both single duct and multiple duct, as many as seven ducts having been used in local practice. The outer tube is iron, usually being standard weight steam pipe. The ducts are wooden tubes, the wood being treated with creosote or some similar preparation in order to secure durability. In the single duct form for low voltages the wooden tube is directly in contact with the iron tube, but when the single duct is used for conductors of higher electro-motive force, and when multiple ducts are used, the wooden ducts are served with cord, which acts as a mechanical separator from the iron pipe and also to separate one duct from another, and the interstices are filled with a mineral product, such as asphaltum or tar. The material at present used for filling is one of the petroleum products. These completed tubes are butted together, end to end, the exact coincidence of each duct with its continuation in the next tube being secured by very simple means, and this butted junction is made water and air-tight by clamping around it a cast-iron box, which is filled with compound similar to that used in the tubes. The manholes or junction boxes of this system are iron castings, with loose outer cover and an inner cover which is made by a rubber gasket and an application of hot beeswax and tallow.

The Cummings system has a number of advantages peculiar to itself. The wood surface of the duct is not hygroscopic, so that no condensation takes place except on the sides of the iron manholes, where it does no harm. The coefficient of friction between copper and the prepared wood is very small, so that there is no trouble in pulling a great length of heavy conductor. Then the material seems to be permanent in its electrical and mechanical qualities, and it is of necessity used of considerable thickness, so that there is no possibility of conductors in different ducts being brought within the sparking distance of any ordinary voltage. I don't think that the makers of this conduit will err as did the cable manufacturers in placing cables on the market which gave a high laboratory test, but infallibly punched out under the practical conditions of use.

There have been several attempts made by manufacturers of paper-lined tubes to introduce these into service as underground conduits. So far I do not know of any permanent success. There was one very rank failure in this city, of which most of you who observe such things are probably cognizant. A conduit system was laid of paper tubes stacked in a box filled with roofing tar and having manholes which were supposed to be water and air-tight. Into the tubes were drawn wires braided or lightly insulated with rubber tape. It was a mistake to insulate the wires at all, because the braiding received moisture from the air at each reduction of temperature, and held it in contact with the paper of the ducts. The surface of the paper was moisture-resisting, but the material was not so saturated as to be permanently damp-proof, and in due time there were frequent failures of insulation and burning of the conduit. Please note that it is a good thing (other things being equal) to have your duct material fireproof, because if anything goes wrong with an electric light conductor a blaze is the usual consequence. The troubles which were incident to the design were aggravated by the carelessness of the builders, who made many connections into the manholes in a rough-and-ready way, which was certain in time to allow the entrance of water to these manholes, and from them to the tubes. Finally the system, after suffering still more from neglect of men who should have taken care of it, was abandoned altogether.

I don't know any reason why a paper tube system should not be brought into practical shape. It is still being exploited occasionally by one tube manufacturing concern, and they may ultimately make it a go. Their circulars, however, distributed within the current year, show a lack of appreciation of the practical conditions of conduit work which prevents my hoping for an early success.

There is a tight system occasionally used which deserves mention, although its limitations are such as to prevent its general adoption. It is the Brooks oil-insulated conduit. In this method an iron pipe is laid and made tight. Into it the conductor, wrapped with a fibrous covering, such as jute, is drawn, and finally the tube is pumped full of heavy oil, such as resin oil. Arrangements are made so that a pressure of a few pounds to the square inch is maintained on the oil, so that there is no tendency for water to leak in and displace it. A very perfect system of glands and packing has been devised for service connections and terminals. The chief claim made for this system is that the oil prevents the development of a permanent fault sequent to a high-tension discharge from the conductor to the iron pipes. Experience in this country with oil-insulated transformers would justify this claim, but it is doubtful whether under any usual conditions the complications of the system would be warranted in order to secure this special advantage.

Coming now to the much more common conduit systems, which are neither tight nor insulated—which are tersely described by a practical man as "horizontal holes in the ground into which you can pull cables"—the tendency today is to accept as standard for all classes of electrical work a duct of vitrified brick or terra cotta. There is a strong minority opinion in favor of a duct called "cement-lined," molded within a sheet-iron shell from a mixture of Portland cement and sand—an artificial stone. The fault of the latter is its very high coefficient of friction in conjunction with the usual lead sheathing of cables, which makes the pulling of the cable through a cement-lined duct a much greater undertaking than through an equal length of tile. The advantage of the cement-lined duct is that it can be produced in greater lengths than is possible with tile or terra cotta, because of the warping of the latter in the kilns.

Ducts of asphaltic concrete were once used, these having been the earliest in the market, and, having been cleverly exploited, were laid down in many cities, including Detroit. They were expensive, which is their chief fault. The minor faults were liability to damage from the burning out of a cable and from proximity to steam pipes or other sources of heat to be found under city streets.

The tile ducts are made both single duct and multiple duct. Both the Camp single duct tile and the McRoy multiple duct terra cotta conduit have been largely used in this city. For multiple duct conduit the Camp tile is laid in tiers in cement mortar exactly like bricks in a wall, the matching of the ducts being secured by drawing a mandrel into each tile as it is laid. The McRoy conduit is usually laid the same way, but sometimes, when it is important to exclude water, the joints between sections are sealed by a wrapping of jute bagging, saturated with hot asphalt. This is an old plan, having been used with the Lynch conduit, which was a tile of square cross-section (usually 10 × 10 ins.) having a horizontal partition, which carried one layer of cables, while a second layer rested on the bottom of the tile.

The standard duct for telephone purposes is 3 ins. in diameter, and electric light men are finding this also a convenient size, so that it is now the most frequently called for. It holds three or four small cables or one large one, or a multiple conductor feeder cable for a three-wire system very conveniently.

Manholes are almost always built of brick. When a fairly large manhole is needed it is hardly possible to use anything but brick. Cast-iron manholes of small sizes can sometimes be placed, but the inflexibility of this material makes it very inconvenient when the street is crowded with pipes and conduits having prior right of way. I have seen and used concrete manholes, some of them of large size, but the same difficulty affects these, as they must be rammed up around a mold, which mold cannot be placed in position if there is any obstruction in the hole. If you have to build a new mold for every hole, there is no profit in concrete work; but with brick you can build the manhole of any shape required, and you may write it down that no two manholes in a city job built in these latter days will have the same dimensions, and you will be fortunate indeed of one-half of them are so nearly of contract shape that the contractor will not claim "extras" on them.

The sewer connection is necessary in manholes frequently used. Those seldom opened and far from sewers may be allowed to fill up with water, if the cables are of the lead-covered type, as pumping out occasionally will be cheaper, in the long run, than sewer connections. Ventilation sufficient for the dilution of gases to a safe figure can usually be had by perforation of the manhole cover, but where much gas leaks in, special provision for ventilation should be made.

The best practice, as exemplified in recent work, is to lay the tile conduits on a foundation of concrete and to fill the space between the stack of tiles and the sides of the ditch with grout. The use of the foundation is obvious. The side filling is preferred to back filling the earth, because it does not require to be rammed, and so the danger of displacing the tiles from their alignment is avoided. On top of the whole construction a layer of concrete is advisable, although not always necessary, its use being to protect the tile from picks and bars in the hands of careless excavators.

There is no standard practice in the construction of branches from main lines of conduits. The telephone companies commonly use sewer tile, employing the usual sweep bends for angles. The joints between the sewer tiles are made with cement mortar. Where there is risk of disturbance, or where the space for the branch conduit is limited, as it is in many alleys and courts, wrought-iron pipe is used. There is a tendency to use cast-iron, which I think is preferable to either wrought iron or tile for runs of one or two ducts, in that it is neither so easily injured as the tile, nor does it rust out, nor be eaten by electrolysis, so soon as the wrought-iron pipe. Most of the wrought-iron pipe on the market to-day is not iron at all, but is steel, and it does not last underground as long even as the old-time wrought iron.

In two recent installations of single duct conduits in parks, namely: the West Park plant, in Chicago, and in our own Island Park, wooden pump logs have been used for ducts. This material, when kept constantly wet, lasts for a very long time and is a very satisfactory conduit. In soils which are only moderately damp the saturation of the wood with creosote much increases its useful life. From my experience in Chicago, I should fear that the pump log laid close to the surface, as it is in the West Park installation, will not last for any length of time, but on Belle Isle, where the soil is not only saturated with water, but where the wood has been creosoted, I think the conduit will be as durable as any other material except tile. The objection to tile is the difficulty of joining it in a wet ditch, such as is usual on the island, the cement being washed out of the joint at once, and the certainty that tree roots, particularly those of the willow species, would find their way into the conduit and in time fill the ducts with a vegetable network, which would prevent the drawing in or out of cables. The creosoted wood is not touched by tree roots at all, and the joints, having been sealed with roofing tar, will permit no access of the suckers.

My idea of a perfect single duct system is a cast-iron pipe laid exactly as is a water main, the joints leaded and calked and the occasional curves or large radius being obtained, as they are in water main practice, by offsetting each length of pipe a little. It would be necessary to ream out the spigot end of each length of pipe, and there should be provided plenty of flanged lengths to be used instead of the leaded joints in working through occasional wet places. The pipe ought to be thoroughly cleaned at the foundry and coated hot with Angus-Smith compound. Special sweep fittings would be used for laterals entering buildings or led up poles.

To turn from conduits to cables: In all departments of electrical work the lead-covered cable is now used. There are very few engineers laying cables not protected by lead these days. Some estimable gentlemen have been so "rattled" by the ravages of electrolysis that they have advocated a return to the use of non-leaded cables, substituting for the lead a saturated braid or tape. I have not heard anything of this idea for the last eight months, and its advocates have had the worst of it in all the arguments of the earlier part of the year. But this agitation has had the good effect of bringing about the study of the use of protective braids or coatings to be applied over the lead, and it has been found, as usual in our cable practice, that the European engineers have developed this system very thoroughly. Any of the cable companies will now furnish leaded cables having an external coating. One of the best of these consists of, first, the coating of the cable with an asphaltum compound which does not harden in cold weather; next, the lapping around the cable on top of this

coating of a double layer of dry manila paper; third, another coat of asphaltum, of a different composition, which sets harder than the first coat; finally, two servings of jute twine, saturated with asphalt, the second serving being applied in the reverse direction to the first one. This process, when carefully carried out, forms an ideal protection from electrolytic action. It is important to see that the twine is saturated before it is applied to the lead, as many cable manufacturers serve the lead with dry twine and attempt to saturate it afterward, which process is almost certain to fail of its object.

The telephone companies, as I have already mentioned, have adopted a standard cable, called the "conference cable." This contains a sufficient number of pairs of small wires, usually 100 pairs, each pair being twisted on itself and the total number being made up into a loose strand. The insulation of the individual wire is a loosely applied strip of paper, dried by heat, but not filled in any way to prevent absorption of moisture. The lead sheath is forced by a continuous process over the strand of twisted pairs, and the ends of each length are sealed against the entrance of moisture by a filling of paraffine and a lead cap, which remains in position until the cable has to be jointed to the next length. Of course, a perforation of the lead would admit moisture to the cable, and, as the atmospheric moisture present on an ordinary damp day is quickly absorbed by the dry paper, very great care has to be taken to maintain the integrity of the lead sheath. The lead is not pure, but is alloyed with 2 or 3% of tin, which makes it considerably harder and less liable to stretch during the process of pulling in through the ducts. This alloy of lead and tin is almost universally used by American cablemakers. One maker prefers a pure lead with a surface coating of tin applied to it after the cable is otherwise complete. I don't find that this method is any better than the more common one.

The telegraph companies on their main lines have taken lately to using paper-insulated cables, not differing materially from those designed for telephone work, but most of the telegraph cables now underground are rubber insulated, the different wires being bunched under a tape and braid, and in all the later practice having the lead sheath over all. Telegraph cables for submarine work are always rubber insulated in American practice. The Atlantic cables and other long-distance cables are not made in American factories, and are, except when laid in tropical seas, insulated with gutta-percha. The usual finish of a submarine cable is a bedding of tanned jute, with an armoring of galvanized iron wires over all. Cables laid in water infested by the teredo navalis are sometimes protected by a copper or brass strip instead of the galvanized iron wires. Bunched cables for use by the American telegraph companies under rivers and estuaries have of late years been lead-sheathed over the bunch of rubber-insulated wires and before application of the jute bedding. The telephone companies avoid submarine cables as much as possible, because of the bad effects of such cables on the talking capacity of the lines. When compelled to install them they usually follow telegraph practice.

Electric light practice to-day is about evenly divided between paper-insulated cables and rubber-insulated cables, both lead covered. The paper cable for electric light work differs altogether from that for telegraphic work, in that the paper is laid on closely and is saturated with a viscous compound. The paper is not laid on very tightly; the different layers are so disposed as to allow of a slight slip when the cable is bent, so preventing breaking of the paper, because it is necessary to avoid the presence of any cracks or crevice, extending from the copper of the conductor to the lead sheath. Such breaks in the continuity of the insulation are weak points, permitting the passage of high potential discharges, which would be withstood by the body of the insulation. The viscous filling has for its object the restoration of continuity by the slow movement of the filling into any crevice that may form. You will notice that in an electric light cable with paper insulation the paper is a true insulator, while in the telephone cable the paper simply serves to preserve the distance between the individual wires, and the air is the insulator. Rubber cables are preferred for high-tension work—5,000 volts and upward—in our practice, although there are theoretical reasons in favor of paper. Only one of the numerous fibrous insulations with which the market was once filled now remains in the market. That is the Waring "ozite" filled cable, which has excellent mechanical qualities combined with a low cost. The other fibrous insulations have been displaced by paper. In choosing betweeen rubber and paper insulation, two considerations must be taken into account which are too frequently overlooked. The first is the possibility of the lead sheathing, on which the insulation of a paper-covered conductor finally depends, being destroyed by electrolysis. If electrolytic action is known to exist in the earth where the cable is to be laid, of course the lead should be protected in the first place, no matter what the insulation may be. But if the risk is only a remote one, liable to follow on future extensions of street railway lines, it is well to note that a rubber-insulated cable may continue in use long after the lead is perforated or destroyed. The other consideration, which some engineers or other of my acquaintance overlooks at least once a year, is that with high electro-motive force a definite space must be occupied by insulation all around the conductor to prevent what is called "punching-out"—that is to say, the passage of a discharge from conductor to lead sheath, so that in many cases it is better to use a greater thickness of the cheaper insulation—to wit, paper—rather than a less thickness at equal cost of the more expensive material; and this, although the thin rubber wall will give a higher insulation, as tested in the usual way, than will the paper. In designing a cable system a thorough study should be made of the details of junctions and terminals. There are plenty of good cables to be had, and there are enough good jointers to make the splices in the cables, but there is a sad lack of details, such as switches, lamp connections, and service boxes, fit to stand the ordinary accidents of use at high electro-motive force.

In closing, it is necessary to say a few words about the systems of cables or conductors which do not permit of the withdrawing of the conductors, including in this the well-known solid systems, so-called, of Edison and of Ferranti. The best known of these systems in the United States is the Edison tube, wherein three solid copper rods are wrapped with cord so as to preserve their distance from one another, and placed in an iron pipe of sufficient size, the ends of the pipe being closed with hard rubber plugs and the interstices being filled up solid with an asphalt compound. The tubes are usually 20 ft. long. The joints between these tubes are made by slightly flexible links, and the links and the ends of the tubes are protected by a turtle-shaped casting, which is finally filled with compound similar to that used in the tubes. There is more electric energy distributed over this style of conductor than over any other in use in the United States. The Edison tube system is to-day essentially the same as when it was introduced fourteen years ago, and in our own city several miles of tubing laid in 1886 are in use at the present moment, and have been continually in use since first laid. The special virtues of this method of arranging underground conductors are that its method of joining conductors permits the making of service connections at the junction of any two tubes, and that the tubes form a sufficient mechanical protection to the conductors against any of the usual disturbers of the subsoil. The only instances in this city in which these conductors have been injured by street excavations have been those where the work has produced a general settlement of the soil or a partial landslide, causing the joints (which are not designed to resist longitudinal strains) to open out.

The celebrated Ferranti tubes have been described so often and have been so limited in their use that they require no description from me. You will remember that they contain concentric conductors designed to carry current at a pressure of 10,000 volts; that the insulation is paper soaked with ozokerite, and that the joints are accurately turned tapers, male and female. The system was lacking in flexibility, and required an unusual order of skill and specially accurate machinery in making up the sections.

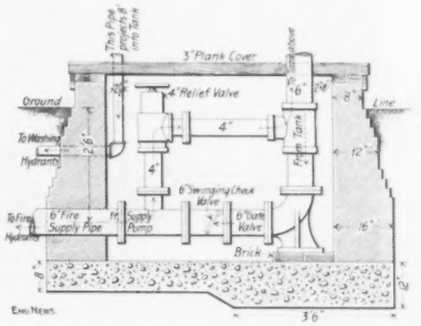
Some eight years ago another solid system of conductors was tried in several cities and under different names. The conductors were stranded copper cables without insulation, laid in a matrix of asphalt, the asphalt being confined by a wooden trough and covered with plank. The plan failed because of the softening of the asphalt, allowing the conductors to sag together, or in other instances, where the asphalt was sufficiently firm to resist sagging, through the opening of cracks allowing water from the soil to reach the conductors and cause short circuits. I may say that the finding of an asphalt insulating compound which will remain viscous at minimum temperature of the subsoil of the Northern American States and will still be firm enough at maximum temperature to prevent sagging of imbedded conductors is still an unsolved problem.

Finally, there have been laid underground a great many cables simply buried in the soil. This is a favorite practice in Europe, and the European cable manufacturers make cables armored with iron strip or with interlocking wire specially for this work. In this country such special cables are not regularly on the market, and the practice is not in favor, because of the continual tearing up of our streets for different purposes without proper supervision of the excavators. Lead covered cables are laid occasionally in streets not likely to be disturbed, a bed of concrete or a creosoted plank being laid on top of the cable to give notice to the careless excavator. I am sorry to say that my own experience shows that neither concrete nor plank is effective. Our local wielders of the pick are not expected to think, and, being directed to open a trench, will work on faithfully through either concrete or plank, varying their straightforward digging only by an occasional "undercut" to the obstruction. At least two Polish citizens of Detroit have been educated during the last three months as to the inadvisability of undercutting small sections of concrete uncovered in trenches. One of the two knows now that he struck an electric light cable, and that the destruction of the point of his pick and the accompanying blaze were due to physical causes. The other man disappeared for the day, after his early morning experience of this kind and at last accounts was still firmly convinced that there exists on Washington Avenue, in front of St. Aloysius Church, a short and direct passage to the nether regions.

THE WATER SUPPLY SYSTEM OF THE CHARLESTON CITY RY. CO.

In installing a system of water supply for the power house and car barn of the Charleston City Ry. Co., Messrs. J. G. White & Co., of New York and Baltimore, the engineers for the plant, have adopted a system possessing some novel details. A single elevated tank supplies two systems of mains, one of which has fire hydrants, but no other openings, and the other leads to the washing nozzles in the car barn, and the various washbasins, closets, faucets, etc., about the shops and offices.

The main for the fire hydrants is 6 ins. in diameter at the tank, and reduces to 3 ins. at points farthest away. The main for the ordinary supply is of 2½-in. pipe, and its mouth projects through the bottom of the tank a distance of 8 ft., so that the water stored in the tank cannot be drawn off below this point. There is always available in the tank for fire purposes, therefore, at least 8 ft. depth of water.



Valves at Outlet of Tank for Water Supply of Power House and Car Barns, Charleston City Ry. Co.

We show in the accompanying cut the arrangement adopted to create a fire pressure some 30 lbs. greater than that due to the head of water in the tank. The pumps which supply water to the system deliver into a branch from the fire hydrant supply mains, and under ordinary conditions the supply passes up the 4-in. branch pipe and past the spring relief valve at its top into the tank. This valve exerts a resistance of about 30 lbs. per sq. in., and the elevation of the tank gives about 20 lbs. additional pressure, so that the total pressure in the fire mains whenever the pumps are running is about 50 lbs. per sq. in. At any time, when the pumps are idle, the fire hydrants have still a pressure of about 20 lbs. upon them and at least 8 ft. of water to draw upon, as already explained. Thus a stream can be put onto a fire at once without waiting for the pump to start, and the volume of water in the tank would in almost any conceivable case be sufficient to supply the hydrants until the pumps could be started.

The advantage gained by this system, of course, is that a fire pressure corresponding to a head of about 100 ft. is obtained without incurring the expense of a 100-ft. tower and tank. It will be noted, however, that all the water pumped for ordinary uses has to be pumped against the full fire pressure, whereas it is used at a pressure some 30 lbs. less. If the amount of water used is considerable this may mean quite an added expense in the cost of pumping. In our issue of Jan. 4 and April 5, 1894, we illustrated some automatic shut-offs for tanks which appear to us superior to Mr. White's device. They have the advantage that under ordinary conditions the water is pumped at only the head due to the level of the water in the tank, but in case of fire the tank is automatically shut off and the pressure in the pipes can be raised to any point within the capacity of the pumps.

A NEW ROLLING MILL for universal plates is about to be erected at Homestead, Pa., by the Carnegie Steel Co., according to a Pittsburg dispatch in the "Iron Age," of Dec. 23. It will have the largest capacity for universal plates of any mill in the world. It may be well to explain that a "universal" plate mill is one having adjustable vertical as well as horizontal rolls, so that plates of any width up to the capacity of the horizontal rolls may be made, with edges made true by the vertical rolls, thus dispensing with the necessity of shearing the edges.

COAL STORAGE PLANT OF THE TAMARACK MINING CO., DOLLAR BAY, MICH.

To get the benefit of the low lake freight rates, the mining companies operating in the Northern Peninsula of Michigan ship their coal by boat from Cleveland, O., and other ports on the Great Lakes during the summer months. This necessitates the storage near the mines of the coal used during the winter when navigation is closed, and some of these storage plants are of large size and very elaborately equipped with machinery for sorting and handling the coal. One of the most recent of these plants was built by the Tamarack Mining Co., at Dollar Bay, about 14 miles from Calumet, Mich., in 1896, and in the accompanying illustrations we give its principal structural features. Fig. 1 shows the steel skeleton in the process of erection; Fig. 2 is an end elevation showing the location and operation of the coal-handling machinery, and Figs. 3 and 4 show details of the towers and derricks.

The capacity of the Dollar Bay storage plant is 50,000 tons, and the construction is almost entirely of steel, which was selected by the owners in preference to wood, after a most careful comparison. The building is 175 × 428 ft., and its construction is clearly shown by the drawings.

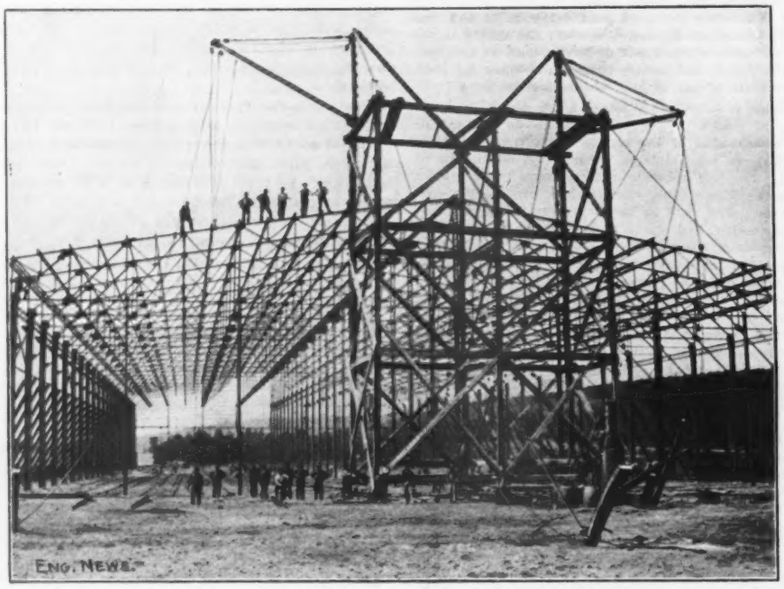


FIG. 1.—STEEL FRAME OF THE DOLLAR BAY COAL STORAGE PLANT IN PROCESS OF ERECTION.
The Gillette-Herzog Mfg. Co., Minneapolis, Minn., Contractors.

The sides and ends of the building are constructed of I-beams which rest at the lower end on separate foundations, and at the upper end lean against the main vertical posts of the building. The girders are attached to these battering I-beams. The covering of the building is of corrugated iron. It is evident, however, that if the corrugated iron were to take the thrust of the coal it would have to be of an exceedingly heavy gage, and in order to avoid this the sides of the building were planked over directly upon the girts, the planking being attached very securely. Upon this planking the corrugated iron covering was attached. Below the eaves the sides of the building are open in order to admit the passage of the cars. The roof of the building is composed of steel trusses and purlins covered with corrugated iron in the usual manner.

The method of unloading the coal from the boat and depositing it in the building is fully illustrated by the drawings. In general the scheme is as follows: Three movable steel towers run the complete length of the building. These towers are connected to the building by movable trusses supported at one end by the towers themselves, and at the other supported on a rail which is attached to the side of the building. These towers and trusses are operated by sprocket wheels and chains. Boom derricks are attached to the top of the towers as shown, and are capable of being operated in various positions in relation to the tower. Special platforms are built on the tower for the support of the hoisting machinery. The buckets used are of the Bogie type, which descend by wire rope from the end of the boom into the hold of the vessel, and after being filled are raised until they strike the framework of the carriage, when the carriage immediately begins to travel up the boom, until it is finally tripped into the hoppers at the top of the tower.

The openings in the sides of the building are spaced to gage with the hatches of the vessels, and the three towers can be moved together so as all to be unloading from the same boat at one time. After the coal has been deposited in the hoppers it is released and falls into the small cars standing on the platform below. This platform is hung in connection with Fairbanks' scales and in this way every carload of coal that goes into the building has its weight recorded in a convenient manner. Attachments are also supplied for the screening of the coal where necessary.

The movable platform referred to works on a pivot and after the car is filled the operator moves

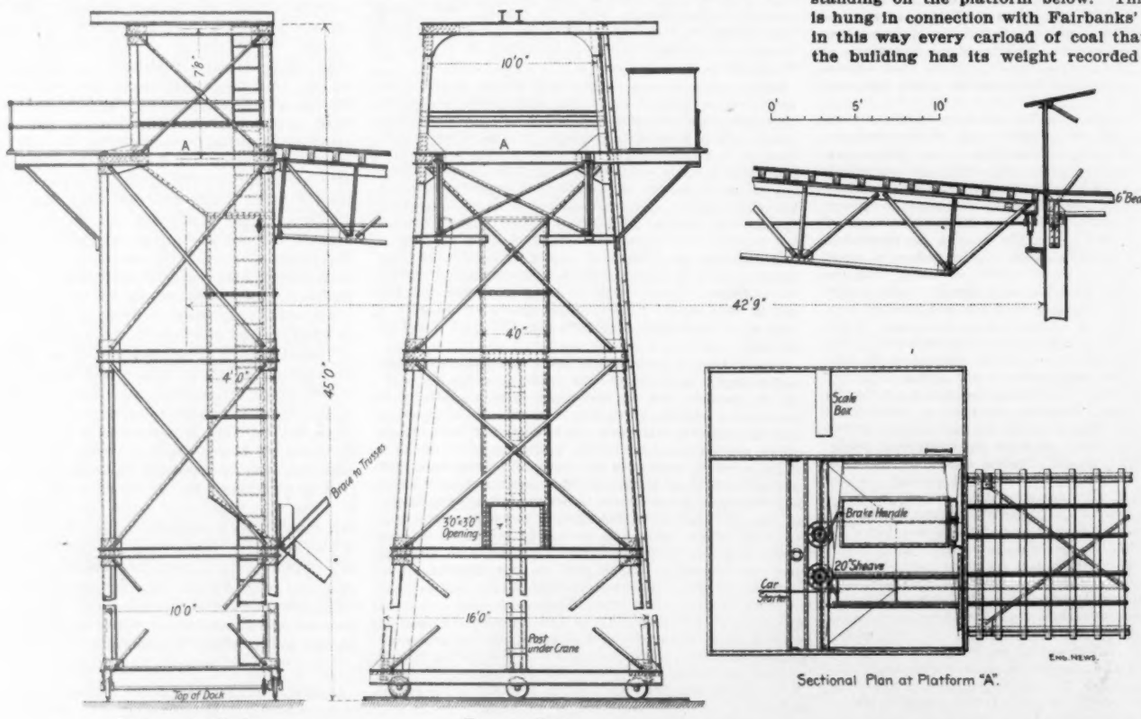


FIG. 3.—DETAILS OF TRAVELING DERRICK TOWERS, DOLLAR BAY COAL STORAGE PLANT.

his lever, thus tilting the platform to the same grade as the trusses which connect the building with the tower. These trusses carry the light rails upon which the cars run. Each tower is fitted with two sets of platforms and two sets of cars. These two cars are connected together by a rope passing round a suitable arrangement of pulleys, and when one car is on the platform being loaded the other car is in the building, and as soon as the operator tilts the platform to the grade of the trusses the loaded car starts down them pulling the empty car back into position. The full car travels across the trusses and through the side of the building and is tripped at the point where it is desired to unload the coal.

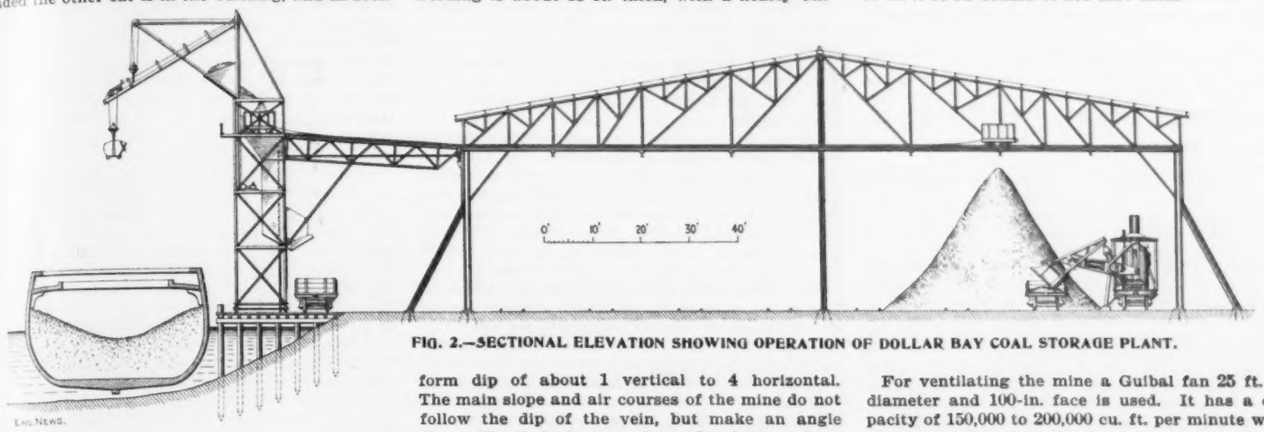


FIG. 2.—SECTIONAL ELEVATION SHOWING OPERATION OF DOLLAR BAY COAL STORAGE PLANT.

Complete sets of tracks run across the building at each opening, these tracks being supported on I-beams, which are suspended from the trusses on a suitable grade. The length of the rope connecting the two cars is adjusted by winding it upon a drum attached to the car, so that the full car reaches the tripper and is dumped a little ahead of the moment when the empty car reaches the platform, the impetus of the empty car being sufficient to carry it into place after the full car has been dumped and comes to rest.

Coal is put into the building with the appliances above described, it is stated, at the rate of 100 tons per hour. The towers are also supplied with secondary hoppers, into which the coal can be turned instead of into the primary hoppers mentioned above. These secondary hoppers discharge immediately into the railway cars upon the tracks below, thus when coal is unloaded from the vessel it may either be deposited in the building, as described, or may be delivered directly into the cars and hauled to the mines for summer use. The advantage of the double system of cars is that one car is always in place on the platform ready to be loaded, and it is not necessary to wait until the car has been dumped and brought back into position before loading can be continued.

In re-handling, the coal is taken from the building by means of steam shovels which run upon rails set to standard gage longitudinally of the building. These shovels dig their way into the pile and deposit the coal into the cars, which run upon parallel tracks. This, of course, makes it impossible completely to fill the building, as it is necessary to leave one corner in which the shovels can start work. The operation of these steam shovels for this purpose is said to be very expeditious and economical.

The contractors for this plant were the Gillette-Herzog Mfg. Co., of Minneapolis, Minn., Mr. Frank J. Llewellyn, Chief Engineer. We are indebted to Mr. Llewellyn for the information from which this article has been prepared.

COAL MINE PLANT AT DIAMONDVILLE, WYO.

By W. P. Hardesty.

Within the past three years there has been developed and built in southwestern Wyoming one of the most substantial coal mining plants to be found in the country, considering how thinly settled the region is. At Diamondville, Wyo., which is on the Oregon Short Line R. R., and 39 miles west of Granger, its eastern terminus, the Diamond Coal & Coke Co., of Salt Lake City, has, since July, 1894, opened up and is now mining an extensive bed of coal, shipping to points in Wyoming, Montana, Utah and several other western states. The coal is a good quality of fairly hard bituminous. The main bed which the company is working is about 13 ft. thick, with a nearly uniform dip of about 1 vertical to 4 horizontal. The main slope and air courses of the mine do not follow the dip of the vein, but make an angle therewith, their downward grade being about 23%. The main slope is in 2,000 ft., being parallel on each side by an air course, with a 50-ft. column of coal intervening. There are over 2½ miles of level passages at the eight different levels of the mine, all but that at the first level being double. The main slope is 12 ft. wide by 8 ft. high, the levels 10 × 7 ft.

At the mouth of the main slope is the engine-house. The engine is a double Reynolds-Corliss, with cylinders 28 × 60 ins., and a rated capactiy of 1,500 HP. It was built by E. P. Allis & Co., of Milwaukee, Wis. The foundations are 28 ft. × 38 ft. × 11 ft. deep, of stone laid in cement. The hoisting drum is 8 ft. diameter with 5 ft. face, and has a capacity for winding 7,000 ft. of 1¼-in. cable. The cable is made of plow steel. The drum runs loose on the shaft, and is secured by band friction clutches worked by an auxiliary steam engine.

The engine has foot brakes on the crank disks and compound post brakes on the drum, operated by an auxiliary engine, and reversing gear operated by a third auxiliary engine. The engine runs at 60 revolutions, giving a speed of about 18 miles per hour to the pit cars. At present 12 cars are hauled at a load, though the engine is good for 16.

The cars are made by the Watt Car Wheel Co., have a weight each of about 1,500 lbs., with a capacity of 4,000 to 5,000 lbs. of coal. The capacity of the engine for hoisting when at a depth or distance of 6,000 ft., is 1,600 tons per day of ten hours, and it can be used to hoist from a depth of 10,000 ft. The tramway is 3 ft. gage laid with 40-lb. rails.

Steam is now supplied by four 72-in. × 16 ft. return tubular boilers of 125 HP. each, and by two 66-in. × 16 ft. boilers of 100 HP. each.

For ventilating the mine a Guibal fan 25 ft. in diameter and 100-in. face is used. It has a capacity of 150,000 to 200,000 cu. ft. per minute with the present extent of workings, though only about 75,000 cu. ft. is now needed, secured by a speed of about 25 revolutions per minute. The fan is run by an 18 × 30-in. Corliss engine.

For handling the coal outside there are five railway tracks, with the usual style of bar and mesh screens for separating the lump, nut and slack. The dust is gotten rid of by using a No. 4 blower driven by a double 10 × 12-in. engine, an air pressure of 4 lbs. blowing the dust through 1,000 ft. of 7-in. pipe to the waste grounds.

The company is now mining about 1,300 tons of coal per day, with a capacity at present of about 2,000 tons with one shaft.

The company's engineer is Mr. William E. Jacobs, of Salt Lake City, who has designed the plant and done all the engineering work.

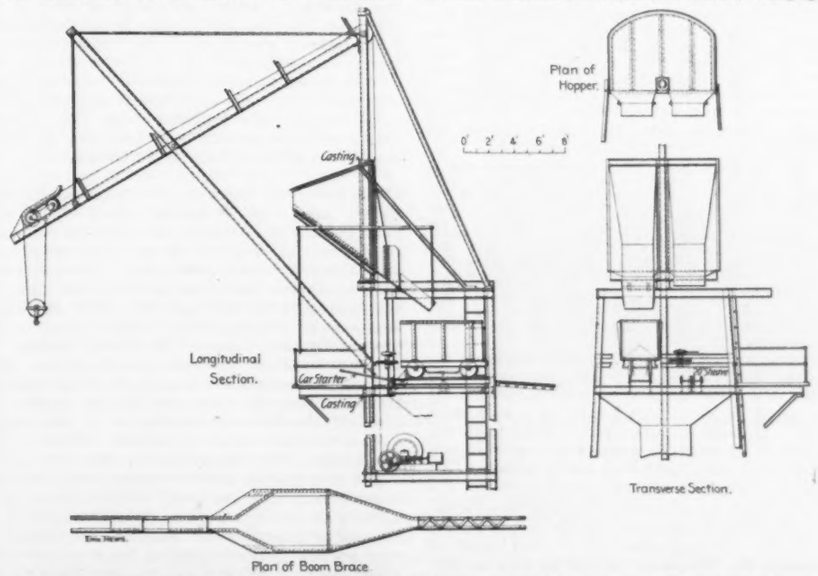


FIG. 4.—DETAILS OF UNLOADING DERRICK AND MACHINERY, DOLLAR BAY COAL STORAGE PLANT.

THE RECLAIMING OF COAL HEAPS, or the extraction of good coal from the mountains of culm in the Pennsylvania anthracite coal regions, is seriously engaging the attention of the Reading Railroad Co. During the past season 50,000 tons of merchantable coal were taken from dirt heaps at the worked-out Kalmia mine, and on this coal the company makes a profit of $1.00 per ton. The washing machinery is simple and effective, and the coal is taken out and graded to lump, pea, buckwheat and rice sizes. Some of these culm piles are 200 ft. high, and cover 10 acres, and the aggregate of good coal thus hidden in years of plenty and waste must be an enormous one.

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The fact that American locomotive builders have recently booked orders for 58 locomotives for European railways, underbidding in open competition, and in their own markets, the largest English and Scotch manufacturers, is discussed editorially in a recent issue of our London contemporary, "The Engineer." The editor acknowledges very candidly that the American locomotive builder turns out engines more cheaply than his English rival does, but maintains that he is able to do this because "the American locomotive is a cheaper engine to build than the English engine, and is built more cheaply," and also because "the American builders live by their reputation; they are not troubled with any precise specifications." In support of this last statement the "Engineer" treats its readers to the following remarkable bit of news

> In the United States the great firms construct engines to certain standard patterns, and they say to the purchaser: "There are half a dozen types from which you can choose; if you find nothing to suit you among them, then we must ask you to try some other maker." One result is that it is possible to build to stock, a thing which no English or Scotch firm dares to do save on a very small scale indeed, and by building to stock they can execute orders promptly. It is scarcely necessary to stop to explain to our readers how much this system of building only standard engines cheapens work. Our makers have invariably to build to special designs, constantly involving the use of new patterns, and to most rigid specifications.

In other words, our contemporary solemnly asserts that the practice of the American locomotive builder is to construct a lot of locomotives and set them up like a row of tea kettles on a shop shelf for the purchaser to select from; if he finds one that suits him, well and good; and if he does not, the builder waits until a more easily satisfied customer comes along. If this statement were not seriously made by an engineering journal of reputation it would be almost too silly to notice, but as it is, we mildly suggest that for the benefit of its readers the "Engineer" should as soon as possible try to disabuse its mind of the idea that American locomotive manufacturers build only to stock patterns, and that "inspection in our sense of the word is almost unknown in the United States."

We speak from knowledge when we say that the American locomotive builders turn out the great bulk of their product to conform to the specifications and frequently to the detailed drawings furnished by the purchaser. Of course their great stock of working drawings and of patterns and templates, enables them to meet the most varied specifications with a much smaller outlay for shop drawings and patterns than would be necessary if all these had to be made new; but the purchaser gets what he wants and can have his peculiar ideas, whatever they may be, carried out as perfectly as they could be in any English workshop.

On the other hand, the purchaser who can specify only the work that he wants his locomotives to accomplish, the grades they are to climb, the trains they are to haul and the speed they are to make, will find the American locomotive builder prepared to furnish plans and specifications of machines which they will guarantee to meet his requirements.

On the whole we are disposed to think that in the course of a year a large locomotive works in America has as many different designs of engines in its erecting shop as do the large English and Scotch firms, and if we are not likewise mistaken the material and workmanship which go into these engines are as closely inspected as they are in similar establishments in Great Britain.

The "Engineer's" contention that the American locomotive is in some respects a cheaper engine to build than the British locomotive we believe to be quite true. The use of copper fire boxes and brass tubes in English engines is certainly more expensive than the use of steel, which is the common practice in America, and there are some other features in which the common practice of the two countries differ of which the same may be said.

But let us again remind our contemporary that this fact has nothing to do with the case. If a locomotive superintendent in Brazil or Australia wants copper fire boxes and tubes, or bronze driving boxes, the Baldwin Locomotive Works will furnish them just as readily as Neilson & Co.

Even if "The Engineer's" ideas of American locomotive shops were correct, however, we fail to see how they would explain the purchase of European locomotives in the United States. Certainly European railways would require locomotives built to their own standards, and if what "The Engineer" says were true, the advantage would manifestly be with the English locomotive builder, who is accustomed to "build to order." The truth is, of course, that the recent success attained by American locomotive builders abroad is due to quite other causes. One of these, unquestionably, is the fact that English builders are just at present hampered in their competitive trade by the machinists' strike, and more largely to the fact that American builders are better equipped to meet quickly and cheaply the requirements of European purchasers. At the risk of starting our contemporary off on its old hobby we will remark also that for the service to which most of the locomotives recently exported from the United States are to be put, the American type of engine is a better machine than the English type.

The paper on "Electrical Conduits and Cables," by Mr. Alex. Dow, of Detroit, which we print on another page of this issue, is a valuable summary of engineering practice at the present time in the laying of wires underground. It will probably be agreed that in most American cities at the present time there are few more important engineering questions than those relating to the proper disposal beneath the street surface of the multitude of overhead electric wires. And by proper disposal we mean permanent disposal. If the placing of wires underground should necessitate the frequent tearing up of pavements and obstructing streets to remedy defects in the conductors or the conduits after they are laid, it might well be said that the change from overhead to underground wires would do more harm than good to the general public. The ideal system of disposal of electric wires, and for that matter of all pipes and conduits beneath the street surface, would be in a subway tunnel, accessible at all times for necessary repairs and additions, and for making service connections. But the public is not yet educated up to this, and we must still go on turning over and over the soil beneath street surface and spoiling street pavements until there is no more room to be found for pipes or conduits.

What may be called present best practice in electrical conduit construction is a system of ducts, buried in the earth and accessible through manholes placed at intervals. The liability of any such system to mechanical injury through other street excavations is well known, and we believe this is rather greater in the case of tile, terra cotta or creosoted wood ducts than in the case of iron pipes embedded in concrete. Probably the greatest amount of trouble with underground cables thus far experienced has not been due to mechanical injury, however, but to electrolytic action due to return currents of electric street railways. The end of this trouble is not yet; but the danger is now so well understood and the means of guarding against it are so well known that injury to underground circuits by electrolysis at the present day must be taken to signify that those in charge of the plant have not maintained proper vigilance.

Another problem which is coming to the front is the effect of high potential alternating currents upon the insulation of underground cables. The use of alternating currents at very high potential is rapidly increasing. Even the Edison companies, which only a decade ago were fighting against the use of the alternating current by every means in their power, are now arranging to generate alternating current at high potential at stations on the water-front, or on the outskirts of cities where land is cheap and water for condensation can be had, and will transmit alternating current at high potential to substations for reduction in pressure and transformation. It goes without saying that wires carrying any such currents must go underground; the authorities would not for a moment tolerate them overhead in the city limits.

Now, it is stated on good authority that a long-lived cable to transmit alternating currents is yet to be made. The insulating material in all such cables is a rubber, gum, wax or similar compound of a more or less plastic and viscid nature. As long as this viscid, or semi-fluid condition is maintained, the insulation is perfect; but the alternating current subjects the molecules of the insulating compound to such stress that it gradually crystallizes. When this occurs, as every electrician knows, its insulating properties are enormously decreased, and the cable should be condemned. Some cable manufacturers have attempted to overcome the difficulty by using as an insulating medium paper soaked in an insulating compound; but in time this insulating compound also dries and crystallizes, and the cable loses both its flexibility and its insulating quality.

If the above statements are well founded, the problem of carrying alternating currents underground is not so simple as has been supposed. It must be remembered that a cable suitable for carrying a high potential current underground is very expensive. If such cables must be renewed every five years or seven years, or every ten years, it means a much heavier cost for carrying current underground than most engineers have contemplated.

We shall be glad to hear from any of our readers who may have had experience in this field. The subject is one of great importance to the profession, and it is to be hoped that some of the well-equipped laboratories in the engineering schools may undertake its investigation.

An important announcement is made in the December "Proceedings" of the American Society of Civil Engineers. The Board of Direction has ordered that hereafter the House of the Society shall be open every day, except on Sunday, from 9 to 22 o'clock, or from 9 a. m. to 10 p. m. On Sunday the House will be open from 2 to 7 p. m. As this order entails some additional expenditure, the Board trusts that members will justify it by a considerable attendance. With the handsome and very comfortable quarters available it would seem that the privilege here granted should be appreciated by many members of the Society, and especially by the younger men. The library is now so housed that it is more accessible and valuable for reference than ever before; and with an abundance of space on hand the number of technical books and periodicals should be, and doubtless will be, rapidly increased. This alone, aside from all social features and the opportunity for making acquaintances and exchanging experiences, should attract members to the new House of the Society.

FOG IN TUNNELS—AND ELSEWHERE.

On several mornings, during the past month or two, New York and its vicinity have been enveloped in a dense fog, which has greatly delayed the movements of the ferry-boats and the suburban trains, and also the trains on the elevated railways. Quite a serious collision occurred on the Manhattan Elevated as a result of the fog on Dec. 9.

In the account of one such morning's delays published in the "Evening Post," on Nov. 16, the reporter remarked, apropos of the hour or more of delay which some of the elevated trains experienced:

It probably occurred to more than one of the belated passengers that the fog could not, in the case of an underground road, play such havoc with the time of busy people.

Now the "Sun" newspaper, as some of our readers may know, has always been an implacable foe to the New York Rapid Transit enterprise. Any mention of Rapid Transit affects it as a red rag affects a bull; and, besides, it loves not the "Evening Post." Therefore, when the above casual remark in the "Post's" columns was espied in the "Sun" office, the editor's sharpest satire was brought into play, and the "Post" was held up to ridicule for suggesting that fog conditions would be different in a tunnel from what they were in the open air.

We may remark here that, to the best of our belief, the "Sun's" persistent and virulent attacks upon the Rapid Transit enterprise are responsible for a good share of the opposition which it has encountered, and especially for the prejudice against it which exists in the minds of many intelligent and progressive men. Included in this list are quite a number of engineers, whose information and opinions on this subject should be much more trustworthy than that of the editor of a daily newspaper if they had kept their minds unbiased.

We do not mean to say that the men to whom we refer are aware that their opinions on this topic were formed through their reading of the "Sun." People are seldom conscious of the exact source from which their prejudices arise. It is a trait of human nature, however, that first opinions are frequently formed from trifling causes; and, once formed, testimony far stronger than that which originally gave them birth will not suffice to change them. Thus it has come about that many of the arguments used by the "Sun" in its fight against the Rapid Transit enterprise, although based on fallacies and falsehoods, have found credence and support among many whose professional education and experience should have taught them better.

Included among those who have come more or less under the "Sun's" spell in this matter is the editor of our esteemed contemporary, the "Railroad Gazette." When the casual remark of the "Evening Post" reporter above quoted was noticed in the "Gazette" office, the editor sharpened his own satirical pencil—and very sharp it can be made on occasion—and wrote:

How does the able editor propose to keep fog out of the tunnel? Even our lamented friend, Greathead, never expected to be able to do that.

About this time, also, another well-known engineer, Mr. Gabriel Leverich, M. Am. Soc. C. E., whom we must assume also to be an unconscious victim of the "Sun's" influence, wrote a letter to the "Evening Post," designed, we believe, to set that journal right on this matter, by explaining that there would be just as much fog in the tunnel as outside, hence the Rapid Transit trains would be no better off than the trains on the elevated roads. The editor of the "Evening Post" did not print Mr. Leverich's communication, however, so Mr. Leverich wrote to the "Sun," setting forth the neglect of the "Post" to accept his correction of its error, and the "Sun," of course, printed the letter. The editor of the "Railroad Gazette," too, returned to the attack and rounded up the "Post" in the following paragraph:

A FOGGY EDITOR.

Mr. Gabriel Leverich writes to the New York "Sun," saying that the "Evening Post" has said editorially that with a tunnel road New York travelers would not be troubled with fogs; that he has explained to the editor of the "Post" that a fog may be worse in a tunnel than on the surface, and that so far his letter has not been printed in that candid journal. Mr. Leverich need not be surprised; his experience must be very common. Three weeks ago we asked the able editor how he proposed to keep fog out of a tunnel, but have had no answer.

Finally, in the "Gazette" of Dec. 17, we find another contribution to our knowledge of this subject, which we print as follows:

FOGS AND THE TUNNEL ROAD.

Brooklyn, Dec. 14.

To the Editor of the "Railroad Gazette:"

Permit me to thank you for having called my attention to the paragraph printed in your issue of Dec. 10, entitled "A Foggy Editor."

I fancy that the editor is not only "foggy," but "foxy." In the evening of the day in which my communication relating to "underground fogs" was printed in the "Sun," there appeared in the "Evening Post" an editorial referring to underground transit, in which it was stated: "The opponents of underground transit have discovered another tremendous obstacle to the movement of trains in a tunnel. . . . Now a fog is cited as constituting, 'under certain atmospheric conditions,' a barrier which might block the entire system."

You will notice that the editor had not the courtesy to publish my communication to which this marked reference is made; if he had so done, the statement and counter-statement would have been presented to the public, and the strength of his position or mine could have been judged thereby.

I am amused that he should quote me as an "opponent" of underground transit. So far, I have not anywhere publicly expressed my opinion. It, however, is not too late; such would be a most futile undertaking for the relief of crowded traffic of the busy hours of New York, promoted by those who are personal opponents to the present elevated railroad systems; by those who are interested in securing large contracts from the city, and honestly and earnestly by those, and evidently a large number of citizens, ill advised as to the utility of the plans noted. That it would be, and surely within the lifetime of the present generation, a failure—either as a means of transit or as a financial investment—I have no doubt.

G. Leverich.

This is all highly amusing; and we trust it made the editor of the "Post" feel properly ashamed. But the point that interests engineers is: Would or would not a prevalent fog extend to the interior of such a tunnel as that planned for the New York Rapid Transit Ry.? Mr. Leverich and the "Gazette" editor seem sure that it would; but they have offered no evidence from either theory or experience in support of their belief; and this is a question of too much practical importance to be settled dogmatically. Suppose we study this question a little.

Turning to Russell's "Meteorology," we read:

The vapor ascending from warm water or warm moist ground into cold air above it produces fog. The air in contact with the water contains more moisture than the cold air higher up. On account of its lightness it ascends. Mixing with the cold air above, it is cooled below the dew point and part of the vapor condenses as fog.

Certainly no such conditions exist in a tunnel as those named above, and we presume it would not be seriously contended by anyone that fog would be formed in the tunnel. The idea of Mr. Leverich and the "Gazette" editor, we presume, is that when the whole city is wrapped in fog, the tunnel also would be filled. But would it? Is the interior of buildings filled with fog when it is dense in the streets? We know, of course, that the different atmospheric conditions inside cause the disappearance of the fog. This is true even of places like cellars and basements which are not heated, and which are more or less open to the air.

Let us, however, search for a closer parallel to the proposed tunnel railway. We can find it in the Boston Rapid Transit tunnel; and, with the possible exception of the City & South London electric railway in London, it affords the only example that we now recall of a tunnel railway operated by electric traction solely. Existing tunnels on steam railways are, of course, filled with smoke and steam from the locomotives; and where these are thoroughly ventilated, as is the Pennsylvania R. R. tunnel in the city of Baltimore, the great volume of outside air forced into the tunnel tends to make the atmospheric conditions inside the same as those outside.

The Boston subway, however, appears to be a perfect parallel to the proposed New York Rapid Transit tunnel. It is near the street surface, yet with few openings to the outer air. Only electric cars pass through it, and the city itself, we believe, is quite as subject to fogs as New York. The experience in the Boston tunnel, therefore, should definitely settle the question whether the trains in the New York Rapid Transit tunnel will be obstructed by fog as are the trains on the elevated roads. Desiring an authoritative statement upon this matter, we addressed Mr. H. A. Carson, M. Am. Soc. C. E., the Chief Engineer of the Boston Transit Commission, and append his reply as follows:

Sir: In answer to your letter of Dec. 10, relating to the condition of the atmosphere in the subway during foggy weather:

Assistant General Manager Frank Barr, of the Boston & Maine R. R., informs me that the trains on his road were delayed on account of unusual fog on March 3 and 10, June 4 and 5, Oct. 27 and 28, Nov. 3, 5 and 16, Dec. 4, 1897. The other steam railroad official of whom I inquired states that his records do not contain the dates when they suffered through fog. The subway, as far north as Park St., has been in operation since Sept. 1, of this year. All of the engineering parties who have worked in the subway have been questioned as to what they noticed about fogs on the above-mentioned days or at other times. Last spring, before the completion of the subway to Park St., when there were considerable areas of roof uncovered, one of the observers noticed a fog entering the subway in the vicinity of the openings. It did not, however, obscure vision where the lights were burning. One observer noticed a slight fog Nov. 16 (since the subway was opened), but states substantially that it caused no practical obstruction to vision. None of the other observers recall any fog whatever.

General Superintendent Rugg, of the West End Street Ry. Co., states that he has no knowledge that there has ever been any indication of fog in the subway since his company began to operate it. I have been in the subway frequently, and have never noticed any fog.

Yours truly, H. A. Carson, Chief Engineer.

Office of Boston Transit Commission, 20 Beacon St., Boston, Dec. 22, 1897.

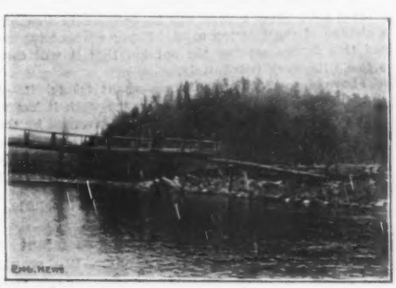
We have no doubt that both Mr. Leverich and the editor of the "Gazette" will be pleased to accept Mr. Carson's statement as a final settlement of the question as to fogs in tunnels. As to fogs elsewhere—we trust that they who have so rightly reprimanded the "Post" for its suppression of evidence in the case will set that journal a good example by publishing corrections of their own statements on this subject, which we have quoted above.

We reviewed in our last issue, the present status of the New York Rapid Transit enterprise, and will not again discuss it at this time. We may, however, express our belief that not a few of the arguments which have served to prejudice many influential men against this great work would be found on careful and unprejudiced investigation to be like the one we have just dissected—founded on fog.

LETTERS TO THE EDITOR.

A Primitive Cantilever Bridge.

Sir: While engineering in the Tennessee mountains last year I saw a rather novel bridge, a negative of which I enclose. Doubtless the Forth bridge is more imposing, but certainly this one is as truly a cantilever. The mountaineers, in erecting this structure, first threw upon a rough timber bent a 30-ft. log, on the shore end of which stones and rocks were piled. This serves as an approach to and support for the suspended span. The latter was also a single log, secured to the support by a ¾-in. bolt. Of



A Cantilever Bridge in the Tennessee Mountains.

course, the vibration is, in bridges of 50-ft. span, excessive, but as the structure is for the accommodation of pedestrians only, no evil results follow. I learned that the mountaineers use bridges of this type quite generally wherever a stream is too wide for a simple foot-log or its banks are too low to furnish supports sufficiently above its level.

Very truly,

Edward B. Day.

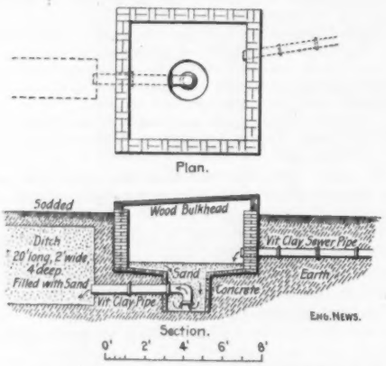
Hopedale, Mass., Nov. 27, 1897.

Sewage Disposal for a Country House at Branford, Conn

Sir: The disposal of house drainage in the country, particularly along the sea shore, where means must be found other than that of draining into the sea, is a problem which confronts every country householder at the very beginning of an attempt to introduce modern sanitary appliances. The following description and cuts show a modification of the prevailing drainage system which is so simple in its construction and so successful in its workings that those who, from an engineering standpoint,

are professionally interested in the subject, have urged a publication for the general benefit.

What we will call the "Thimble Farm System" consists of an excavation, which, when walled up with an 8-in. brick wall, is 6 ft. sq. in the clear and about 3 ft. deep. The bottom is cemented and slightly inclined toward a sump-pit in the center, which is 2 ft. in diameter and the same in depth. This hole is cemented on its sides only. A ditch 20 ft. long, 2 ft. wide and 4 ft. deep, commencing 1 ft. from the outside of the brick wall, is led off in any convenient direction. A 5-in. vitrified drain pipe, with an elbow, is laid from the sump-pit to the ditch. The elbow, with the open end down, is placed about 4 ins. from the bottom of the hole. The tunnel from the hole to the ditch is then filled and packed solid. A little cement is used in laying the pipe, in order to insure solidity. The ditch is then filled with sand to within 8 ins. of the top, when loam is used to completely fill it. It is then seeded or turfed over.



Sewage Screening Chamber and Sub-Surface Disposal Trench for a House at Branford, Conn.

The sewer pipe is led in through the brick wall about 8 ins. from the cement bottom. The sump-pit is then filled with sand and the cement bottom is covered with sand to the depth of about 3 or 4 ins. A frame work of wood is set in a thin layer of cement on the top of the brick wall, and two doors, opening either way, are set on an incline, which gives it the appearance of a bulkhead. The top of the wall is about 5 ins. above the surface of the ground.

The sewage matter entering the drain spreads itself over the entire surface, and is then filtered through the sand on the cement bottom and through the sand in the sump-pit. The clarified fluid passes up through the elbow, through the cement pipe, and is absorbed by the sand ditch and the surrounding earth.

This device has been in use about nine months. At the present time there is about 2 ins. of solid matter on top of the sand, presenting a semi-dry appearance. Before winter sets in this will be removed and applied to fertilizing, together with the sand, including that in the sump-pit. This will be replaced by a fresh supply of sand. It is expected that twice a year will be sufficiently frequent for a change of the filtering sand. Experts who have examined this device express the opinion that it will continue to do its work indefinitely.

The above described device gives about 36 sq. ft. of filtering surface, and proves ample for the work it has to do. The size would, of course, have to be governed by the amount of sewage to be provided for.

Up to the present time there has been no perceptible odor arising from it, and the device has given perfect satisfaction in every particular.

Thomas B. Doolittle.

"Thimble Farm," Branford, Conn., Oct. 29, 1897.

(The plant described by our correspondent is certainly an interesting experiment. We would be more inclined to guarantee its continuous successful working, however, if the pipe were extended down the sand-filled ditch with open joints. It may be worth while pointing out, too, that the sand ditch can only dispose of the water if the surrounding soil is porous. If the soil is clayey a drain would have to be laid from this ditch to some watercourse.—Ed.)

Concerning Our Comments on the Test of a Hawley Furnace.

Sir: On the editorial page of the issue of Dec. 23 of your valuable journal is discussed my report on two trials of a 350-HP. National boiler, made at the tin plate works of Marshall Bros., in Philadelphia, one trial being made with a Wilkinson stoker, burning an inferior grade of anthracite (buckwheat), and the other being made on a Hawley water grate, burning Clearfield coal.

You state that "the conclusions drawn are deserving of comment," and that my words, "saving in fuel by the use of the Hawley furnace," appear to you as "directly calculated to mislead," and that they are "quite without justification."

Marshall Bros. had been running their plant with the Wilkinson stoker and buckwheat coal for some two years. They were not satisfied with the results obtained, finding that the coal cost per ton of output was higher than it had formerly been with a common furnace with Clearfield coal. They determined upon throwing the stokers out, after having failed to find them adapted to the use of Clearfield coals. They were convinced that the use of buckwheat anthracite, on any grate, was a loss when it cost them as much per ton as bituminous coal.

In looking over the field they found the Hawley furnace in use, and were led to believe that it would be well adapted to their needs. The Hawley people offered to put in their furnaces and take in payment a percentage of the saving in coal cost of operation that should be actually effected. Having closed a contract for the Hawley grates, it was necessary to determine the usefulness of the new furnace by tests, and both parties to the contract called upon me to settle the matter.

I made the tests as an observer, giving no direction to the management of the fires on either test, but noting they were well controlled in each instance. My report was published by the Hawley company, and from it you derived your information. The report is not misleading, nor is it calculated to deceive. It is clear and pointed, and says that the tests were to determine:

1. The efficiency and capacity of the boiler burning Shamokin buckwheat coal, costing $1.90 a long ton, on the grates of a Wilkinson stoker; and

2. The efficiency and capacity of the same boiler burning Eureka (Clearfield) run of mine coal, costing $1.90 a long ton, on the grates of the Hawley down-draft furnace.

The tests actually showed that Marshall Bros., under their circumstances, could run their plant at a fuel cost of 36.3% less with the Hawley furnace than with the Wilkinson stoker. The tests were commercial, and were solely to determine the coal cost to Marshall Bros., in operating their plant.

In no sense was the report misleading. I cannot but feel but that you failed to properly digest the report before writing your criticism. I am not responsible for the publication of the report, but am the author of it, and you assailed my judgment and findings.

I am aware of the fact that a paper controversy is never satisfactory, and I here rest my case.

Very truly yours, J. M. Whitham.

131 South Third St.,
Philadelphia, Pa., Dec. 24, 1897.

(In our editorial comments on the boiler tests referred to we purposely omitted to state that the tests and the report were made by Mr. Whitham. We thought it possible that the words "Saving in Fuel by the Use of the Hawley Furnace," which are printed in the Hawley Down-Draft Furnace Co.'s circular in large type, might have been written by him inadvertently, and that if he had been a little more careful he would have written a more exact statement, such, for instance, as "saving in cost of fuel by the use of Clearfield coal, costing $1.90 per ton, burned in the Hawley furnace, as compared with a poor grade of anthracite buckwheat coal, costing the same price per ton, burned on a Williamson stoker." We did not assail Mr. Whitham's "judgment and findings," nor did we even criticise him for what we considered might be only a want of sufficient care in the use of words. What we did "assail" was the action of the Hawley Furnace Co. in sending out the printed report of this test as an advertisement of its furnace, and calling especial attention to the line "Saving in Fuel by the Use of the Hawley Furnace," by printing it in display type. We doubt not that Mr. Whitham himself will agree that the "saving" was really due to the use of a coal of much less cost in proportion to its heating power. His report was doubtless not calculated to deceive or mislead the clients to whom it was rendered; but its publication and distribution by the Hawley Co. seems to us to deserve severe criticism.

We may remark in this connection that cases have frequently come to our knowledge where tests or reports made by engineers have been of a character which would be exceedingly misleading to the general public, although not at all to the parties for whom they were intended. In every case of this sort, ought not the engineer, for his own protection, to see to it that the report is not made public, except under his supervision and accompanied by such explanations as will prevent misunderstanding of its conclusions?—Ed.)

Sir: The editorial article appearing in your issue of Dec. 23 in reference to the tests made at Marshall Bros.' tin plate works, in Philadelphia, is not a fair one. You say that the words "saving in fuel by the use of the Hawley furnace" are directly calculated to mislead the reader. If you doubt the correctness of the two tests, we would refer you to Mr. J. M. Whitham, who had charge of them; if you do not doubt the correctness of the results, we certainly claim that "the saving in fuel by the use of the Hawley furnace" was certainly 36.3%. While we do not desire to get into any controversy on this matter, still we feel justified in requesting that you publish the report of Mr. Whitham in full, a sample copy of which we inclose, so that the reader can judge for himself whether the article is misleading or not. The fact remains that Marshall Bros. were paying $1.90 per ton for their anthracite coal used with the Wilkinson stoker and that they did and are now paying $1.90 per ton for the soft coal used with the Hawley furnaces. Consequently, we still claim that the "saving in fuel by the use of the Hawley furnace" is approximately as was shown by the competitive tests made by Mr. Whitham. We trust that you will see fit to publish the article in toto, which we consider will not be misleading to any of your mechanical readers.

Yours truly,

Hawley Down Draft Furnace Co. of Pennsylvania,
W. F. Tatnall, General Manager.

720 Girard Building, Philadelphia, Dec. 27, 1897.

(Our remarks appended to Mr. Whitham's letter above will serve as a partial answer to Mr. Tatnall's letter. We regret that space prevents our complying with the request to print the report in full. We do not find on renewed examination, however, anything in it to cause us to alter our previous criticism. In this copy, as in the one previously sent us by the Hawley Co., the words "Saving in Fuel by the Use of the Hawley Furnace," are printed in large black type, and in other places in the report we find such lines as "Gain in evaporation efficiency by the use of the Hawley Furnace," "The gain of the Hawley furnace over the stoker is shown to be," etc. Moreover, in the above letter, Mr. Tatnall distinctly repeats the claim that the "saving in fuel by the use of the Hawley furnace was 36.3%." We respectfully commend this system of registering economy to the attention of every dealer in steam user's appliances. Simply test your rival's device with a bad coal and your own with a good coal, and you can triumphantly point to a "fuel saving" that will attract attention if it does nothing else. By the same token, we are prepared to show that if the engineer of a steam plant will read Engineering News while the good coal is being burned, and smoke his pipe while the bad coal is on the grate, the "saving in fuel" by the reading of this journal will rival the results attained with the Hawley furnace.—Ed.)

The Computation of Strains in Coal and Grain Bins.

Sir: Last year I had some calculations to make in regard to a large elevated grain bin, some 120 ft. high and 38 ft. in diameter, with a part spherical and part conical bottom. The pressure in the sides and bottom, and particularly the problem of determining the stresses at the joints of the bottom in order to proportion the splices, was quite complicated.

The number of different methods in use for computing the pressures caused by granular masses would lead one to suppose that there can be no rigid demonstration of the problem, and in so far as we try to assume that the mass

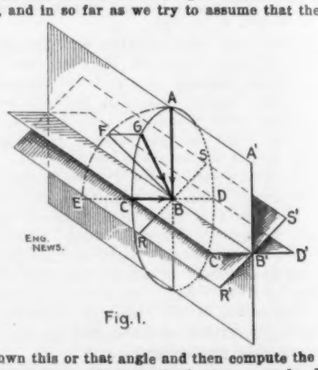


Fig. 1.

slides down this or that angle and then compute the resulting pressure on a plane inclined at any angle, I don't think the problem will stand any rigid demonstration. Rankine starts with the theory of internal pressures, and working along, step by step, comes to the same problem which he states as follows:*

*Rankine—Applied Mechanics, p. 101, § 112.

A pair of principal stresses of any intensities, and of the same or opposite kinds, being given, it is required to find the direction and intensity of the stress on a plane in any position at right angles to the plane parallel to which the two principal stresses act.

He then goes on to prove that if we have one principal stress, for example, A B, Fig. 1, acting on a horizontal plane C' D', and another principal stress B D acting on a vertical plane A' B'; then the direction and amount of the stress on the plane R' B' S' may be found thus: With A B as a semi-major axis and B D as a semi-minor axis, draw an ellipse. Draw a circle from B with radius A B; then draw F B perpendicular to R B S, and from F draw F G perpendicular to A B till it cuts the ellipse. Then will G B be the amount and direction of the pressure on R' B' S'. Of course, we do not have to draw the ellipse at all, for any point on an ellipse may be easily found by the following method. (Here the author described the well-known circle method for constructing an ellipse.—Ed.)

In applying this principal to earth pressures, Rankine says:*

Previous researches on this subject are based (so far as I am acquainted with them) on some mathematical artifice or assumption, such as Coulomb's "Wedge of Least Resistance." Researches so based, although leading to true solutions of many special problems, are both limited in the application of their results, and unsatisfactory from a scientific point of view. I propose, therefore, to investigate the mathematical theory of the frictional stability of a granular mass, without the aid of any artifice or assumption, and from the sole principle: the resistance to displacement by sliding along a given plane in a loose granular mass, is equal to the normal pressure exerted between the parts of the mass on either side of that plane, multiplied by some specific constant. The specific constant is the coefficient of friction, and is the tangent of the angle of repose.

From this he deduces the following for a horizontal surface:

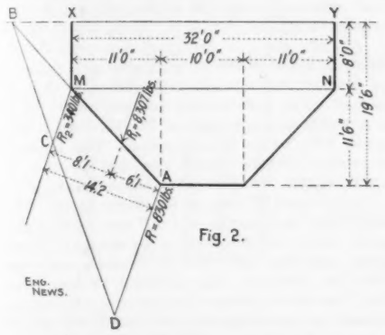


Fig. 2.

In Fig. 2 the dimensions approximate those of the Paterson coal bin. To find the total pressure on the side M A,

$p_x = w\,x$ = max. pressure on horizontal plane.

w = pressure per cu. ft. of coal = 58 lbs.

x = depth below surface.

$$p_y = w\,x \times \frac{1-\sin\varphi}{1+\sin\varphi} = \text{max. pressure on a vertical plane.}$$

φ = angle of repose of coal = 30°.

p_x = weight at O (Fig. 3) and A (Fig. 2) = 58 × 19.5 = 1,131 lbs.

$$p_y = w\,x \times \frac{1-\sin\varphi}{1+\sin\varphi} = \frac{1,131}{3} = 377 \text{ lbs.}$$

p_x = 1,131 lbs. per sq. ft. and p_y = 377 lbs. per sq. ft.; then in Fig. 3 let K O be the inclination of the plane M A, draw O F perpendicular to K O, and locate G as before explained; then G O equals the amount per sq. ft. and direction of the pressure at A on the plane M A; but the pressure varies from this at A to zero at the top surface. (For the method of calculating these values, see Rankine's Applied Mechanics, p. 216.—Ed.) If 830 lbs.

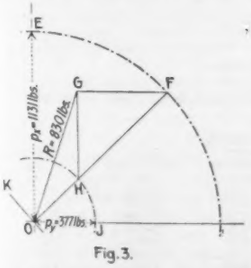


Fig. 3.

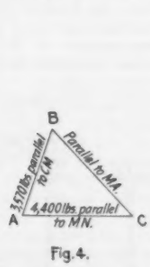


Fig. 4.

per ft. = pressure at A, then R_y = 340 lbs. pressure at M, and 14.2 equals the projection of M A; then the total pressure on M A = ½ (340 + 830) = 585 × 14.2 = 8,307 lbs. total pressure on M A; but the amount of this that goes to M = $\frac{6.1}{14.2} \times \frac{8,307}{1}$ = 3,570 lbs.

*Rankine—Applied Mechanics, p. 212, § 194.

Now, 3,570 lbs., acting at M in the direction C M, would produce a stress as shown by A C, Fig. 4, of 4,400 lbs. in the tie M N. Now, we have left the total pressure on the side M X = $\frac{w\,x^2}{2}\left(\frac{1-\sin\varphi}{1+\sin\varphi}\right) = \frac{58 \times 64 \times 0.5}{2 \times 1.5} = 620$ lbs.

But, of course, M N has to take all this pressure. Therefore, 4,400 + 620 = 5,020 lbs. stress on tie M N per linear ft. of bin, and since each bent supports 17 ft. (about), therefore the stress in M N = 17 × 5,020 = 85,340 lbs. = total stress in M N.

It would thus appear that the stress given by Milliken Bros. is correct. There is one thing that I wish to point

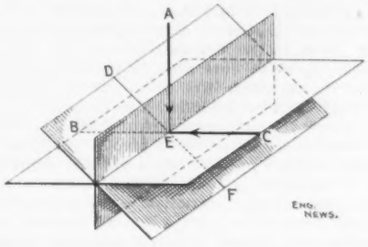


Fig. 5.

out, and I see you have already called attention to it: Milliken Bros., in order to be on the safe side, figured the total pressure on the side as if it ran down straight all the way, evidently thinking this would give them a greater stress in M N than figuring the pressure as I have done. Take the same depth that I have taken, then

$$\frac{w\,x^2}{z}\left(\frac{1-\sin\varphi}{1+\sin\varphi}\right) = \frac{58}{2} \times 19.5^2 \times \frac{1}{3} = \frac{58}{3} \times \frac{380.25}{2}$$

= 3,676 lbs. per lin. ft. and multiplying by 17 = 62,490 lbs., acting at depth of ⅓ × 19.5 from the bottom; therefore the amount that goes to M N = $\frac{6.5}{11.5} \times 62,490 = 35,320$ = stress in M N. Yet Milliken Bros. get 99,100 lbs. by use of the same formula.

Therefore it is readily seen that any such assumption might lead one into some very serious mistake. It is therefore evident that in assuming the side carried all the way down vertically, and figuring the stress on M N, that the stress is only about 0.4 the actual stress in the member, as figured by obtaining the pressure on the inclined surface.

I have gone over the method you give in the issue of Sept. 23, and I think you have made a mistake in counting on the whole mass P A M X as sliding down the surface P A. I have worked out very carefully, under the same conditions that I have already assumed, the stress in M N, by your method, and obtain a stress of 158,000 lbs. Then I tried what seemed to me to be more reasonable; that is, consider the wedge W A P alone as causing the horizontal thrust, and obtain a result of 98,870 lbs., which is more nearly what seems to be the correct result. One other point is that the line of maximum pressure does not bisect the angle between the vertical and angle of repose; this is only true when the top surface is at the angle of repose.

In your issue of Nov. 4 the question comes up as regards the assumption that the pressure exerted by fine coal or grain acts like a liquid; first, so far as the center of pressure is concerned, it does; second, as to the continual jar from machinery, decreasing the angle of repose. I think that point well taken; and in structures of this kind it should always be kept in mind; but in the present case, the mass being so large, a large vibration would be absorbed immediately, and while of course it would affect the angle some, I think that in this case it would be safe to assume the angle is 30°.

In regard to Prof. Howe's method of solution. First, I would like to ask whether (φ) and (ψ) stand for the same function. In the equation of E under the figure he uses (φ) and in the text he uses ψ. (The same angle is meant in both cases.—Ed.) Next, in the text he says: "Since in a granular mass without cohesion the intensity of the pressure upon any plane varies directly with the depth below the surface, the total pressure E may be represented by the triangle E C F, the intensity of the pressure, or E, being represented by C F." Now, this seems to be contradictory. Should it not read: "The intensity of the pressure (at) E being represented by C F?" (It appears to us that your point is well taken, and that the length of line at E should be proportional to the pressure at E.—Ed.) Prof. Howe then goes on to obtain the pressure on the plane C B by the ordinary methods, and arrives at the result that H K = the amount and direction of the pressure on C B.

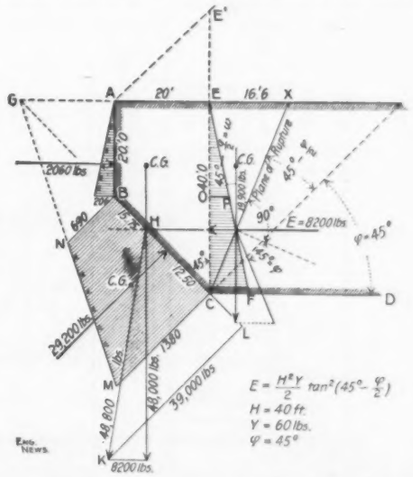
It seems to me that it is too much to assume, with a granular mass, such as fine sand, etc., that because the pressure on a vertical plane is E C (Fig. 5) and the pressure on a horizontal plane is A E, that the pressure on D F can be determined by the parallelogram of forces, with no rigid proof that this would hold true. What I wish to make clear is that it seems to me the only correct method of calculating earth pressures, or pressures similar to them, is to follow the methods of Rankine, which are not based on any assumption or unknown fact. And when it comes to the amount of work required to calculate the stresses by his methods, I think you will find them shorter than the other conventional methods.

Yours very truly, George F. Barton.

231 Lormore St., Elmira, N. Y., Nov. 9, 1897.

(We have received a letter from Mr. Malverd A. Howe in response to a brief comment (Eng. News, Nov. 4, 1897) on a portion of his method of calculating strains in coal bins, which did not seem clear to us at the time. As others may have experienced the same difficulty, the following additional explanation from Mr. Howe is given:—Ed.)

I think a second reading of my communication will show that I use the weight of the triangle GEC merely to determine the intensity of the pressure at C; that is, the pressure per unit of area. This determined, the intensity



of the pressure at B is given by the line NB, if MC represents the intensity at C, since in a granular mass the intensities of pressure in any given direction vary directly as the depth below the surface. Evidently then the total pressure upon BC must equal the sum of all the intensities or the area of the trapezoid NBCM, and this does not include the triangle GAB in the way you suggest.

Sir: I have been following your discussion and letters on pressure of coal and grain in bins, but it seems to me to have been choked off at a very interesting point, that is, the lateral pressure of grain in bins such as are used in our modern American grain elevators. I enclose sketch to scale of a typical bin of small size, and in order that the matter may be cleared up would ask you to compute the pressure per sq. in. or sq. ft. at the points m, n, o. (Fig. 1, p. 426), giving your figures for the same.

It is found in practice that bins burst oftenest at one-third their height from the bottom, which to a certain extent disposes of any hydraulic theory of pressures as applied to grains.

I have tried all the formulae developed in the various letters; have applied the "retaining wall" formula and am yet blind. I have been unable to find a person who has ever computed the thickness of wall necessary to sustain the lateral pressure of grain. The fact is, that in the old style wooden bin elevator, as the size increased, another inch was added to the width of the plank, and even then they were apt to burst. Now that every one is building of iron and steel it becomes necessary on the score of economy in first cost to know what thickness of material will do for circular tanks, and where land is so valuable as to preclude the use of circular tanks it is necessary to know the pressure in order that bracing may be ample in stiffness but as low in first cost as safe for flat surfaces.

Very truly, Horatio A. Foster.

682 Ellicott Square, Buffalo, N. Y., Dec. 11, 1817.

(We requested Mr. Foster to give us more definite particulars concerning his statement that bins usually burst at one-third their height, and his reply is as follows.—Ed.)

My only evidence in support of the statement that bins generally burst at one-third their height is, first, the bursting of one here very recently at that point; second, the testimony of the Superintendent of one of the oldest elevators in this town.

I am perfectly certain that, while the use of hydraulic formula would be more than safe, the results do not show it to be right; as it is a common thing to use a ⅞-in. pine board to close the spout from the bottom of the bin, and in fact the spout itself is a common pine board box nailed or screwed together. Again, one can stop with the hand a stream of grain from the bottom of the highest bin, which

could not be done were it a liquid. In one of the newest elevators built each bin is provided with a good size manhole just above the bottom.

The ordinary wooden bins are built, as you probably know, of plank laid flat, one width for about half way up, and with about two offsets above that. I cannot find that anyone has ever attempted to compute the strains, but has simply added another inch to the width of the plank, as the bins increased in size. This being the case, it would not be expected that the point of bursting would follow any such rule as one-third the height, and the only reason I can suggest for it is that experience has not afforded exact knowledge enough to tell the builder when he has added inches enough. Very truly,

Horatio A. Foster.

(Our correspondent's letters raise some very interesting questions. Before replying to his queries, however, let us see if a little discussion will not clarify ideas regarding the pressures which are produced by granular masses, such as grain or coal.

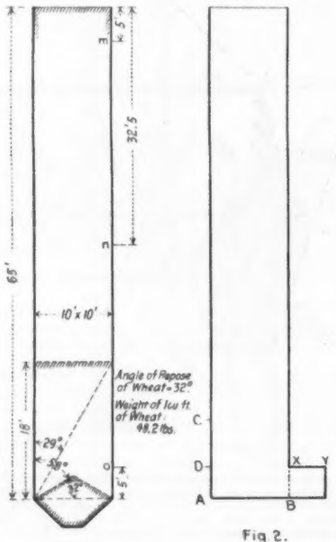


Fig. 1.

Fig. 2.

Suppose the bin shown in Fig. 2 to be filled with grain to its top. What will be the pressure upon its bottom A B? If the contents were water, the pressure upon the bottom would be equal to the weight of the total contents of the bin. This is true because the coefficient of friction of water at rest is zero. Hence there is no friction between the water and the sides of the bin or tank, and all the weight of the water must be carried by the bottom.

With a mass of grain in the bin, however, the pressure upon the bottom is no longer equal to the total weight of the contents of the bin, for there is considerable friction between the material and the sides, so that the sides carry some of the load. In the case of a large grain elevator built under direction of a member of the staff of this journal some years ago, bins similar in shape to those shown in Fig. 1, but some 75 or 80 ft. deep, had their sides so compressed by the friction of the grain against them as the bins were filled that the top of the sides was over a foot lower when the bin was filled than when it was empty. For another example, suppose an ordinary iron pipe, say 6 ins. in diameter, were placed vertically and filled with grain. It will be understood by any of our readers on a little thought that the bottom of such a pipe would have a pressure upon it amounting to only a small fraction of the weight of the grain in the pipe, and the friction against the sides would support most of the weight.

Referring again to Fig. 2, suppose the bin to have a rectangular projection at its bottom, the top of which is the plane X Y. Any one who has observed the action of grain escaping from a spout at the bottom of a deep bin, will agree that the upward pressure per square foot upon the plane X Y, will be only a trifle compared with the downward pressure upon the bottom if that were at the same level. In other words, the internal friction of a mass of grain is such that force is transmitted through it with difficulty, and any change in the direction of the force very largely reduces the amount finally transmitted.

As regards the lateral pressure of grain against a vertical plane surface, such as C D, we can be sure that it is much less than the downward pressure against a horizontal plane at the same level; and likewise that it is much greater than the upward pressure against an inverted plane X Y at the same level; but we know of no experiments that has ever fixed with greater accuracy its actual relation to liquid pressure.

The methods in common use for computing retaining walls, bins and similar structures to sustain a pressure of earth or granular material are really based on the idea that the material (above the cone or plane generated by the angle of repose of the material) is as free to move and exert lateral pressure as a liquid. This method is correct, moreover; for the strains in any such structure must be computed for its greatest load, and it is almost always possible that a granular material may be subjected to shock, jarring or other action which may reduce the friction between its particles and cause it to exert a lateral pressure approaching the pressure which it can exert downward.

To answer our correspondent's question, therefore, we should compute the pressures at m, n and o (Fig. 1), as if the bin were filled with a liquid of the same specific gravity as the grain or other granular substance for which it was designed. We should then proportion the bin on this basis, bearing in mind, however, that the assumed pressures are somewhat in excess of any possible pressures.

We fully agree, however, that the matter of the relation between the downward and the lateral pressure in granular masses is one which ought to be experimentally investigated. Perhaps some of the engineering students who are looking about for subjects for their engineering theses that have not been threshed over by previous generations will take this matter up.—Ed.)

Notes and Queries.

A. J. J. writes to inquire what percentage it is customary to charge for the general designing and detailing of structural iron work. He has had experience in the shops and the designing room of a large bridge company, and has just begun work on his own account, but has had no opportunity of learning what charges are customarily made by engineers engaged in this class of work.

It appears to us that this is an excellent opportunity for engineers who are familiar with this class of work to show a true professional spirit by giving this young engineer the information desired, either through our columns or privately, as they may prefer.

We are well aware that the charges made by engineers for this class of work vary very greatly. It should be possible, however, for some of the older engineers to give some hints to this young man which would be of great service to him. The subject is one, we believe, which interests very many of our readers, and we venture to quote in this connection from a private letter received a short time ago from a well-known engineer:

> The change from masonry to steel construction has quadrupled the labor necessary to honestly and thoroughly prepare plans for engineering structures and the rates allowed by practice do not cover the actual office expenses unless the work be slighted.
>
> I consider it essential to the prosperity, dignity and standing of the profession that the commissions charged for steel structures be advanced to approximate, if not to equal, those charged by mechanical engineers for machinery drawings. I know mechanical engineers who charge 10% on all jobs less than $25,000 and reduce the rates proportionately on larger contracts. The client does not respect the engineer or any other professional man whom he does not pay well.

BREAKING TESTS OF EXPANDED METAL AND CONCRETE FIRE-PROOF FLOORS.

The breaking tests of expanded metal and concrete fireproof floors, described in Engineering News of Dec. 23, 1897, were supplemented on Dec. 20 by the breaking of 19 arches of from 5 ft. to 15 ft. span, making, with the 42 arches previously broken, a total of 61 floor arches loaded to rupture in this series of tests. The construction, dimensions and breaking strength of 17 of these arches are shown in the accompanying table. The two other arches tested were of special construction. The first of these special arches was 8 ft. wide and 15 ft. span. It was built by the use of 5-in. sheet steel beams, made from No. 16 gage steel, weighing 3½ lbs. per lin. ft., and placed 4 ft. apart c. to c. The mixture was Atlas cement one part, sand two parts, and cinders three parts. The load was applied centrally on a strip 6 ins. in width across the middle of the slab. The maximum weight was 8,200 lbs., with a deflection of 1 7-16 ins.

The other arch was a slab of concrete and steel 5 ins. thick and 13 ft. square between supports, the slab having been built to rest on the edges of 3 × 12 ins. timbers framed together. The mixture was the same as just above noted, and the metal was laid in single sheets. The maximum load carried was 11,300 lbs. applied to 1 sq. ft. in the center of the slab. At this load the deflection was 1½ ins. On continuing the pressure the deflection increased to 2½ ins., while the gage fell to 10,000 lbs. At this time, a dropping test was undertaken in addition to the weight, placing a block of wood 8 × 10 ins. immediately alongside the applied load. The first weight dropped on the block was a small beam weighing 70 lbs. and it was dropped 2 ft. twice in succession. The pressure gage receded 200 lbs. under this, but no other effect was visible. Then another beam weighing 894 lbs. was dropped 12 ins. on the same block. This caused a fall in pressure of 1,000 lbs. It was then dropped twice in succession a distance of 15 ins., causing a further reduction in pressure each time of 500 lbs. Then it was dropped 18 ins. twice, forcing the block through the concrete and against the metal, which bagged down below the general bottom level of the slab. The broken area was about 20 ins. square and about 18 ins. from point where the plunger rested. The gage registered 4,500 lbs. at the end of the dropping tests. The slab had lifted slightly at all corners of the frame, but showed no cracks except where struck by the beam.

These tests were conducted by Mr. Geo. Hill, M. Am. Soc. C. E., and were practically a continuation of the 42 tests described in Engineering News of Dec. 23, 1897. For the information from which this description is prepared we are indebted to Mr. Merrill Watson, Manager, Central Expanded Metal Co., of New York, N. Y.

A SUPPLEMENTARY WATER SUPPLY SYSTEM for fire protection in New York has been recommended by President Sheffield, of the Fire Commissioners, Mr. Hugh Bonner, Chief of the Fire Department, and Mr. Foster Crowell, M. Am. Soc. C. E., of 18 Broadway, New York city. Mr. Bonner recommends mains running from both the East and North Rivers to Broadway, and one line of pipe parallel to lower Broadway; also the necessary pumps to supply these mains.

Table Showing Construction, Dimensions and Breaking Strength of 17 Concrete and Expanded Metal Floor Arches Tested at Long Island City, N. Y., on Dec. 20, 1897.

			Concrete.			Expanded metal, No. 10 steel.			
Date built.	Span, ft.	Thickness, ins.	Parts cement.	Parts sand.	Parts cinder.	Meah, ins.	Cross sec., sq. ins.	Maximum load, lbs.	Deflection, ins.
Nov. 19.....	5	3.62	1[1]	3	9	3	0.58	1,650	1⅝
"	5	4.12	1[1]	3	6	3	0.58	6,700	⅝
"	5	3.44	1[1]	2	5	3	0.58	7,100	1[2]
Nov. 22.....	5	3.88	1[1]	2	3	3	0.58	8,000	⅜[2]
Nov. 18.....	5	4.00—4.00[2]	1[1]	2	5	3	0.58	8,600	1⅛[2]
"	5	4.25—3.75[2]	1[1]	2	5	3	0.58	8,200	2½[2]
"	5	4.37—3.62[2]	1[1]	3	6	3	0.58	5,600	3¼[2]
"	5	4.00—4.00[2]	1[1]	3	6	3	0.58	7,200	2½[2]
Nov. 19.....	6	4.24	1[1]	2	5	3	0.60	3,950	1 5-16
Nov. 15.....	6	3.93	1[1]	2	5	3	0.60	4,000	⅝
Nov. 19.....	8	4.38	1[1]	2	5	3	0.65	2,500	1 1-16
"	8	4.51	1[1]	2	5	3	0.66	2,400	⅝
Nov. 20.....	10	4.51	1[1]	2	5	3	1.38[5]	3,700	1½
"	9	4.56	1[1]	2.4	6	3	0.65	3,500	1
"	6	4.37	1[1]	1.6	4	3	0.58	5,000	⅝
"	6	4.44	1[1]	1.6	4	3	0.58	4,500	11-16
"	8	4.12	1[1]	1.5	3.7	3	0.59	3,000	⅝

Note.—[1]Acme cement. [2]Concrete frozen. [3]Thickness of filler of 1 part Rosendale cement, 2 parts sand and 10 parts cinders. [4]Atlas cement. [5]Double thickness of metal. [6]Silica cement.

WATER STORAGE TANKS UNDER AIR PRESSURE AT BABYLON AND SOUTHAMPTON, N. Y.

Compressed air has been an ever-widening field of usefulness. In water-works operation alone it has been put to several valuable uses of late. The earliest of these was its use for the artificial aeration of water for the removal of bad odors or the prevention of low forms of life incident to water deficient in oxygen. Next came the air lift pump, by means of which moving parts in deep wells may be eliminated. The latest application of compressed air to the operation of water-works plants is its use to maintain and regulate pressure in water storage tanks. By this new practice water can be stored in closed tanks beneath or at the surface of the ground, obviating the necessity for elevated tanks or stand-pipes, at the same time keeping the water from the light or any source of contamination and also keeping it cool in summer and avoiding freezing in winter.

The only places where this system has been installed in connection with public water-works, so far as we know, are Babylon and Southampton, N. Y., two small towns on Long Island, each taking their supply from driven wells. The works at Babylon was built by the Sumpwams Water-Works Co., in 1893, and that at Southampton by the Southampton Water-Works Co., in 1894. Mr. Oscar Darling, of 192 Broadway, New York city, was the engineer and contractor of each plant. The storage system installed at these places is covered by U. S. Patent No. 578,505, issued to the late Wm. E. Worthen, Past-Prest. Am. Soc. C. E., and Mr. Darling, and now owned by the Acme Water Storage & Construction Co., of 192 Broadway, New York city.

In its simplest form this system of water storage under pressure consists of a pump, air compressor, air tight water tank, air tank and the necessary connections and valves. The relative sizes of the air and water tanks are proportioned to maintain the normal water pressure until all the water has been expelled from the tank. In operating the apparatus the water tank is filled by the pump and the requisite air pressure is established in the air tank. The desired water pressure is maintained by admitting the compressed air to the water tank. A pressure regulating valve on the air pipe maintains the pressure at a uniform rate. In recharging the water tank both the pump and air compressor are operated at the same time. The air from the water tank passes back through the compressor to the air tank, any deficiency being made up by taking free air through the inlet port.

At Babylon there are two horizontal and two vertical water tanks, with a combined capacity of 100,000 (?) gallons. Two horizontal air tanks are placed alongside the horizontal water tanks, all the tanks being under cover. The normal domestic pressure here is 40 lbs. The air tanks are constructed to carry 150 lbs. maximum pressure. The full air pressure can be used in the water tanks in case of fire.

The arrangement of the Southampton plant is shown by Figs. 1 and 2. Here the water tanks are placed underground, adjoining the pumping station, and the air tanks are mounted above them, unhoused. There are three water tanks, each 6½ ft. in diameter and 45 ft. long, giving a water storage of about 33,000 gallons. There are two air tanks, each 6½ × 40 ft.

When the air tank needs recharging, or while the plant is in operation, the air is forced back into the air tanks by being expelled from the water tanks through the action of the pump, passing through the pipes Nos. 1, 1, 1, 1, and 2, Fig. 2, the check valve on pipe No. 2 retaining the pressure carried in the air tanks. The air passes to the water tank through pipe No. 3, on which is a regulating valve for maintaining the desired uniform pressure. The globe valve on pipe No. 4 enables the full air pressure to be applied to the water, if desired.

By the use of this system of water storage the water can be kept from exposure to light, changes in temperature and contamination while in storage. Any desired pressure can be maintained and an increase in pressure can be effected rapidly, the pressure being under the control of the pumping engineer without the use of devices for operating valves from a distance. In fact, the whole pumping and storage system is under the eye of the engineer. High, low and intermediate pressure may be maintanied from one station, provided separate force mains are employed. It seems likely that a plant with this system could be operated with safety under a lower average pressure than where a stand-pipe or tank is used. With stand-pipes, especially, an unnecessarily high head is pumped against in domestic service in order to provide a volume of stored water for fire protection above the minimum level for effective pressure. In many instances long force mains, with attendant friction losses, are necessary to connect with stand-pipes on distant hills. The system being described saves both this friction loss and the cost of the extra force main to the stand-pipe.

As to the relative expense of securing a given amount of storage by this system and by the ordinary tank or stand-pipe we have no figures for comparison. The amount of storage required and numerous other local conditions would be important factors. Generally speaking it is cheaper to build one large instead of several small tanks. Horizontal tanks of large diameter would not be advisable, but small tanks could be built of any desired length. Perhaps these could be made to form the lower end of force mains.

From the esthetic standpoint there is something to be said in favor of this system.

Most of the stand-pipes and elevated structures in use are far from pleasing to the sight and many of them are very ugly. Of course, such structures can be, and sometimes are, of good architectural design, ornaments instead of blots upon the landscape, but generally good architectural effect is secured at considerable extra cost, although this is by no means always necessary. In this system of storage it is possible to avoid all risk of ugly elevated structures.

In our issue of Sept. 5, 1895, we published a brief note describing a system somewhat similar to the above, but not so fully developed, for use on a small scale. In that system water is pumped to an air tight steel tank, the pump sucking in a small amount of air with each stroke, the air pressure being available until the pump was again started. That system was then controlled by E. Neff & Co., Milford, Ind. In our issue of July 8, 1897, we described and illustrated an apparatus for the water supply of high buildings, designed by Mr. Reginald Pelham Bolton, C. E., Syndicate Building, New York city. Mr. Bolton proposed to use one cylinder for both air and water.

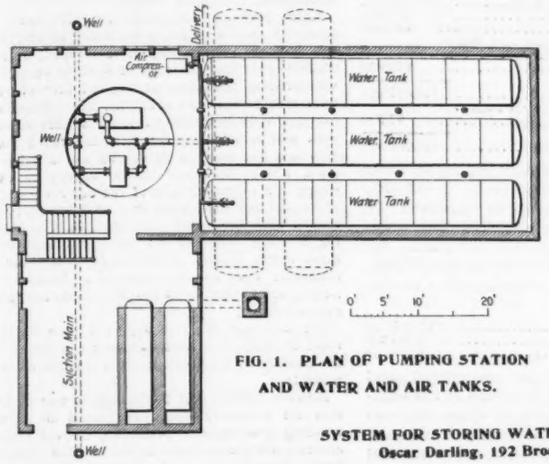


FIG. 1. PLAN OF PUMPING STATION AND WATER AND AIR TANKS.

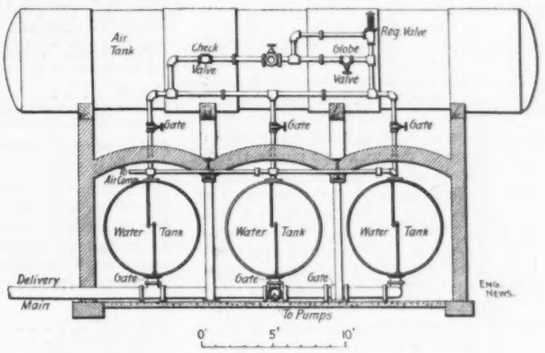


FIG. 2.—CROSS-SECTION THROUGH WATER-TANK CHAMBER.

SYSTEM FOR STORING WATER UNDER AIR PRESSURE AT SOUTHAMPTON, N. Y.
Oscar Darling, 192 Broadway, New York City, Engineer and Contractor.

NOTES FROM RECENT MUNICIPAL REPORTS.

In the report of the Boston Street Department for 1896-7 the subject of sewer ventilation is briefly discussed by Mr. Chas. R. Cutter, Deputy Superintendent of the Sewer Division. Reliance is now placed on perforated manhole covers for ventilation. In summer this works well, except at a few points at the summit of steep grades, where the highest manholes throw out more than their proportionate share of foul air. There are some complaints from super-sensitive persons, to whom the mere sight of a perforated manhole cover suggests unnumbered infectious diseases. Such persons are generally quieted by replacing the perforated cover by a tight one. In winter, when the perforations in the manhole covers are sealed with snow and ice, no ventilation is afforded, so that when a sudden thaw or rain quickly fills the sewers with water, the foul air is expelled, being, the report states, "undoubtedly forced into the houses through traps."

Mr. Cutter recommends that iron ventilating shafts be erected on the sidewalks, just inside the curbs, and connected with the sewers. These, he states, need not be very high in the residential sections, while in the business districts it may be possible to connect them with high chimneys, "by permission of the owners, or by paying for the privilege."

Mr. Benj. Wells is Superintendent of the Street Department of Boston.

A good instance of what may be accomplished by a little firmness in dealing with some of the phases of the labor question is given by Mr. C. N. Taylor, Superintendent of Construction of the Sewers of Natick, Mass., in his report covering the construction of the sewerage system. When the work was started Mr. Taylor was confronted by a vote of the town, as follows:

> Nine hours shall constitute a day's work on the sewerage system, and the pay of the workmen shall not be less than $2 per day.

Mr Taylor, in accordance with this vote, refused to employ any man who could not do a full day's work, notwithstanding the fact that there were many men desiring and needing employment who

were not able-bodied, but were willing to be paid according to their ability. Subsequently the town voted as follows:

That the sewerage committee be instructed to employ only Natick laborers when it is possible to use them and to pay them for what said labor is worth, but not to exceed $2 per day for nine hours' work.

Under this vote Mr. Taylor paid $2 a day to the best men, $1.75 to those not quite up to the average, and $1.50 "to those who, through old age or some inability, were not able to do the hardest work." This plan worked very well. It should be added that the sewerage committee engaged Mr. Taylor partly because he was an out-of-town man, deciding at the outset that such a man would be preferable to a resident as superintendent of construction. Whether a local man would have pursued so courageous and business-like a course as did Mr. Taylor we cannot say, but in many localities it is probable that poor workmen, if properly (or improperly) backed by local politicians, would have received the $2 a day at the start, and the town vote would never have been modified. It is to be assumed that the sewer committee stood by Mr. Taylor in this matter.

The city of Newton, Mass., recently carried a 30 × 36-in. brick drain, a 12-in. pipe sewer, and a 6-in. underdrain beneath the Sudbury and Cochituate Aqueducts of the Boston water-works in an interesting manner. Beneath the Sudbury aqueduct it was necessary to tunnel for a distance of 36 ft. This was done by means of six single-riveted steel cylinders, made of ⅜-in. plate. The largest cylinder was made 6 ft., and the smallest 5 ft. in diameter, with intermediate sizes varying in diameter by 2 ins. The cylinders were forced into the gravel by means of jack screws, the larger cylinder being used first, then the next smallest one inserted in this, and so on. When the cylinders were in place they were filled with concrete, the three conduits being built into the concrete as the work progressed. A similar process was employed at the Cochituate crossing, except that ½-in., instead of ⅜-in. plates were used for the cylinders, and that the play room between the latter was but 1 in. The plate was made thicker because in the first job the cylinders were distorted 1 in. in diameter by their own weight while lying on the surface of the ground, necessitating the use of bracing. Mr. Henry D. Woods, M. Am. Soc. C. E., is City Engineer of Newton.

An exhaustive report on a sanitary sewerage system for Baltimore was made a few months ago by a commission appointed under a resolution of the the city council approved May 25, 1893. The members of the commission were Messrs. Mendes Cohen, Past Prest. Am. Soc. C. E.; F. H. Hambleton, M. Am. Soc. C. E.; and E. L. Bartlett, all of Baltimore. They appointed Messrs. S. M. Gray, of Providence, and Rudolph Hering, of New York city, as Consulting Engineers, and Mr. Kenneth Allen, as Principal Assistant Engineer, all three being members of the American Society of Civil Engineers. Both the commission and the consulting engineers agreed on the desirability of installing the separate system of sewerage, but although the consulting engineers recommended disposal of intermittent filtration the commission reported in favor of disposal by dilution in Chesapeake Bay. The commission bases its conclusion on expediency and economy, while recognizing that filtration would be preferable, if not so much more expensive than dilution. It feels sure, however, that no nuisance will arise from disposal by dilution and that the oyster industry of Chesapeake Bay will not be menaced by it. This latter point is now arousing much discussion in Baltimore, especially as the commission has not followed the advice of its experts. The commissioners urge that the superior merits of filtration over dilution are not worth tripling the annual expenditures for capital charges and operating expenses.

A pamphlet entitled "General Information, City Streets, St. Louis, Mo., 1897," has been prepared and issued by Mr. A. N. Milner, Street Commissioner of St. Louis. The information given is very useful and interesting, covering the cost of and specifications for different kinds of street work, and typical cross-sections of streets paved with various materials.

PRESENT STATUS OF THE NEW YORK STATE CANALS IMPROVEMENTS.

The progress of the work of deepening the Erie, Oswego and Champlain canals and its probable cost in addition to the $9,000,000 already appropriated are fully discussed in a report made to the Executive Canal Committee by Mr. Campbell W. Adams, State Engineer of New York. This report states that it will cost at least $16,000,000 to complete the canal work as planned, or $7,000,000 in addition to the $9,000,000 already appropriated. As was stated in our last issue, the news of this additional expenditure has led the newspapers to charge the canal officials with wastefulness and extravagance in conducting the work. These charges are quite fully answered by State Engineer Adams in his report. Briefly stated, Mr. Adams denies that money has been wasted or used fraudulently, and gives at some length the reasons why the work has cost more than the contract price. According to the report the probable total cost of the canal work will be as follows:

Engineer's estimates for all contracts	$14,448,402
Advertising and inspection paid	147,079
Engineering expenses	512,000
Expenses not in original estimates and difference between engineers' estimates and contract prices	970,019
Total	$16,077,500
Deduct amount appropriated for canal improvement by Chapter 320, Laws of 1895	77,500
Estimated cost of canal improvement	$16,000,000

Several tables which accompany the report show the present status of the work to be as follows: There are 454 miles of canal to be improved. Of this 307 miles are now under contract. The whole work has been divided into 125 contracts, for which the engineer's esimate calls for $14,488,402, which is divided between the three canals as follows:

Erie Canal	$11,031,125
Oswego Canal	1,458,203
Champlain Canal	1,999,074

Eleven of these contracts are completed and have cost $701,094 or $90,481 in excess of the engineer's estimate, though on two of these the cost has been $6,223 less than the engineer's estimate.

In regard to the discrepancy between the original estimates of the cost of the improvement and the figures now given Mr. Adams states that for years the Engineering Department had foreseen that this improvement would ultimately be carried out, and had repeatedly called for an appropriation to enable the surveys to be made and the information collected which would be necessary before reliable estimates could be prepared. This appropriation had been repeatedly refused. Thus it happened that when the Engineering Department was asked for estimates it found itself entirely without proper data upon which to base them. Only twelve days were available in which to prepare the estimates. There were two prepared, one by the Superintendent of Public Works calling for $9,456,000 and one by the State Engineer calling for $11,573,000. Regarding these estimates the report says:

> The fact remains, however, that the legislature fixed the amount which the people were to be asked to ratify at a figure lower than either of the foregoing estimates, and $2,573,000 less than the engineer's estimate.
>
> Finally, the people voted, and by a majority of 276,886, decided that the Erie and Oswego canals should be deepened to 9 ft. of water and have all locks lengthened to double-boat length, and that the Champlain Canal should be deepened to 7 ft. of water. This result was known early in November, 1895, and action toward organizing our departments preparatory for the great work was promptly taken, though very little could actually be done until the Controller had prepared, advertised and sold part of the bonds.
>
> The State Engineer was advised by the Controller that funds from this source would be available Jan. 12, 1896. Within 48 hours thereafter over 200 engineers and assistants had been appointed and assigned to duty. This number exhausted the eligible civil service lists, and a delay of nearly two months ensued before new examinations and eligible lists could be had. Afterward more men were appointed, and the entire length of the three canals—about 454 miles—was put under survey in order to collect the data for the whole work before the opening of navigation the following spring, and while the water was out of the canals, thus revealing as nearly as might be all the conditions to be encountered.
>
> It was also deemed important that the estimates for the entire work should be available before any considerable amount of work was contracted for, in order that we might proceed intelligently thereafter. These surveys are entirely completed, and the plans for the several contracts based thereon are also practically completed, except for a few structures. This will account for what may appear to be an undue cost of engineering, as compared with the amount of construction work done.
>
> The estimates were available early in 1896. They were necessarily based on the judgment of the various engineers in charge of the several sections, and to their credit be it said that the grand total thereof amounted almost exactly to the sum now known to be required.
>
> It was, however, believed that many items had found their way into these estimates that could be omitted, and after revising a few of these covering some of the most important sections, a few contracts were awarded. These covered an amount sufficient to use up the funds provided by the legislature of 1895, and as no more contracts could be awarded till more funds were available, the intervening months were spent in the most rigid scrutiny of every plan and estimate in the effort to bring the total cost within $9,000,000. Every resource for procuring new and cheap materials, for new designs of features where greater economy seemed possible, for eliminating entirely the rebuilding of structures that were already tottering, was tried and exhausted, not without good results, but without accomplishing the object sought.
>
> After revising estimates for all work, they still showed a total (engineer's estimate) of $14,448,402. This will indicate plainly why it is impossible to make $9,000,000 cover the 454 miles of work to be improved. Notwithstanding the apparent impossibility of reducing the total cost to the sum available, the estimates for each contract were repeatedly revised in this effort to reduce cost, and it now appears that the effort made in that direction has resulted in cutting out a large amount of work which experience shows cannot be avoided and which is a necessary part of the other work. Many miles of vertical and slope walls that were known to be urgently needed were eliminated altogether, as well as the rebuilding of many miles of old walls and hundreds of structures which, though known to be in a badly dilapidated condition, were believed capable of lasting a few years longer, until other funds could be made available for their reconstruction.
>
> But it is one thing to say that such items could and must be eliminated, and decidedly a different thing to do the balance of the work in such manner as to make this possible.
>
> Between Buffalo and Tonawanda it was at first believed that all necessary excavation could be made without building new walls or protecting the old slopes, and the contract (Western Division No. 2) was awarded on that basis. This section of the canal is on the very bank of the Niagara River, and runs wholly through a strata of very treacherous clay, which, when wet, will slide on very flat slopes.
>
> The excavation in the bottom of the prism was started, and though the old slopes were not touched, they began to slide into the canal, and a serious crack 1¼ miles long developed in the tow-path, threatening effectually to close the canals. Under such circumstances and in view of the disastrous effect of a break in the banks anywhere on this section, but one thing could be done, viz., to stop the excavation until the banks had been protected. This was done, and the latter feature will entail a cost not originally contemplated of nearly $150,000, though the plans therefor are the cheapest that could be devised after much consultation and study.
>
> The work through Buffalo also gives many startling instances of the unknown quantities incident to this work. This section of the canal, being at the same water surface as Lake Erie, must be drained artificially, and as this had not been done in over 30 years, little could be done or ascertained concerning the condition of the old walls, bridge abutments, culverts, unrecorded sewers, and other structures, or even of the nature of the materials to be excavated, though the estimates for the latter feature are very close. It must be understood that the depth of excavation on this section was from 2 to 4 ft. on the center, while along the walls this depth was from 5 to 9 ft. The condition of the greater portion of the walls, therefore, could not possibly be ascertained until the canal had been drained and the excavations completed. New canal bottom on this section is barely 9 ft. below the low water surface of Lake Erie.
>
> As the latter work progressed it was found that a great part of the vertical walls was not founded on rock, but on a single timber with about 1 ft. of earth intervening between it and the rock. It was found almost impossible to underpin, and save walls so built, and in many cases where it was attempted the walls afterward fell in. It was then seen that while the faces of the walls seemed to indicate a fair grade of work, they were laid up absolutely without bond, the face stones merely forming a veneer for the loose backing that had apparently been simply dumped into place.
>
> The Erie and Genesee St. bridges on the contract are also worthy of comment. As the excavation of these points progressed it was found that the abutments for these heavy bridges were not carried down even to the level of the old canal bottom, but were from 8 to 10 ft.

above same, and therefore 11 to 14 ft. above the new canal bottom. Both were founded on treacherous clay, and at Genesee St. an old forgotton sewer had completely saturated the foundation of the north abutment, in which it ended, and by which its outlet was cut off. The rebuilding of these structures meant a serious outlay, but it was soon found to be unavoidable.

Another section of the work that has been prolific of increased cost over the estimates and of difficulties to be encountered is the "Jordan Level," on the middle division, extending between Locks 50 and 51. This section runs almost wholly through a swamp, underlaid with the most treacherous marl and quicksand, the water surface of the canal being above the surface of the swamp in many places. This feature has rendered the draining of the work a very serious matter.

In other localities the disturbance of the old silted canal bottom has developed a large amount of leakage, and this becomes a very serious matter where it happens in a village, as at Ilion and Fort Plain. Since the water has been withdrawn from the Champlain Canal, a piece of the tow-path about 1,000 ft. in length, on Contract No. 10, but near which no work has yet been done, has broken away of its own weight, and about half the towing path and the walls along same for the distance stated have slipped into the canal. There is nothing to do but to restore the work that has thus been destroyed, and its restoration will add to the cost of Contract No. 10 several thousand dollars. Several similar cases have been reported to us in the last few days.

The foregoing instances of how and why the items of increased cost are constantly being encountered will serve to indicate the corresponding features in nearly all of the other contracts, though probably the cost of the latter will not be increased at the same ratio as those above mentioned.

On the sections for which contracts have been awarded the contract prices will be found equal to a total of about 8% less than that of the engineer's estimates, and the difference will go a long way toward paying for items and quantities not originally contemplated. At the same time the reason for using the engineer's estimates instead of the estimates at contract prices as the basis of the probable total cost in the accompanying tables will be apparent. It is a physical impossibility to determine definitely before these contracts are awarded the total quantities of the various kinds of work that will be required. This can only be determined as the work progresses and unexpected conditions are uncovered.

Various other features of the same import are pointed out by the report, but enough have been given to show to what the extra cost of the work has been due. Mr. Adams sums up his report with the following statements:

(1.) That no surveys for such an improvement of the canals as is now under way had ever been made up to 1896.

(2.) That the estimated cost of this improvement, as submitted to the Constitutional Convention in 1894, was prepared in twelve days, and was, therefore, well known and stated to be practically mere guesswork.

(3.) That the careful surveys and estimates made in 1896, from a thorough examination of the 454 miles of canals to be improved, showed that the probable cost of such improvement was about $16,000,000.

(4.) That an unsuccessful effort was then made to cut out the work to bring the cost within the appropriated $9,000,000.

(5.) That the impossibility of using a large portion of the excavated material for use on the banks of the canals, as originally contemplated, very greatly increased the cost.

(6.) That during the progress of the work of excavation the unpreventable caving in of dilapidated and toppling walls and structures necessitated new construction and increased quantities of large additional expense.

(7.) That contracts have already been let for the completion of about two-thirds of the proposed improvement, which portion it is expected will have been completed at the opening of navigation in 1898. The estimated cost at contract prices of this two-thirds of the work aggregates $7,121,812, though this covers two-thirds of the length and not the volume of the whole work.

(8.) That the contracts already let cover what are believed to be the most difficult portions of the proposed improvement.

(9.) That approximately $7,000,000 additional will be required to complete the improvement.

(10.) That within that sum available we believe the entire improvement can probably be completed at the opening of navigation in 1899.

(11.) That the progress made to date has been as rapid as was consistent with other conditions, and that the whole work might have been under contract now had sufficient funds been available.

(12.) That contractors are required by law to bid upon a definite character and quantity of work, and that they are finally paid for the actual amount of work performed at the contract prices. Under this plan the state always pays for the work actually done for it—no more, no less.

THE OFFICIAL STATISTICS OF THE RAILWAYS OF THE UNITED STATES IN 1896.

From an advance copy of the ninth annual report of the Interstate Commerce Commission's Statistician, the following matter is abstracted relating to the statistics of railways of the United States for the year ending June 30, 1896:

These statistics give the classification and mileage of the railways, amount of railway capital, earnings and income, general expenditures, charges against incomes and general balance sheet for the year. On June 30, 1896, 151 roads were still in the hands of receivers, representing an operated length of 30,475 miles, with capital stock of $742,597,698, and funded debt of $999,733,766. As compared with the previous year, these latter figures show a decrease of $183,075,766 in capital stock, and $319,561,447 in funded debt of the roads in receivers' hands. The Statistician remarks that while the financial condition of the railways of the country is thus shown to be better, the industry has evidently not yet recovered from the embarrassed condition into which it was thrown in the year ending June 30, 1894.

The single track railway mileage in the United States, at the date of the report, was 182,776 miles; an increase of 2,119 miles over the previous year, and representing 6.15 miles per 100 sq. miles of territory, including "land surface" only, and excluding Alaska, and 26 miles per 10,000 inhabitants. In 1890, in comparison, the total mileage was 163,597 miles; and the other figures were 5.51 and 26.05, respectively. In the year covered by the report Georgia led with 234 miles of railway built; California came next, with 202 miles; and nine other states built over 100 miles each. The increase was not localized, though Florida, Georgia, Louisiana and Texas stand prominently among the states showing considerable railway construction. The total mileage of all tracks operated, on June 30, 1896, was 239,140 miles. This is made up of 181,982 miles single track, 10,685 second track, 991 third track, 764 fourth track, and 44,718 miles of yard track and sidings. This total of operated tracks, in 1890, was 208,612 miles; and the increase over 1895 was 3,235 miles. As compared with the years previous to 1893 the betterment of established lines, by the increase of yard tracks and sidings, was small, and further indicate the results of depression in the business of transportation.

The classification of mileage according to organization for operation shows a decrease in the length of line of proprietary companies, and in the length of lines operated under lease and under contract. The resulting increase in the length of line owned by operating companies indicates a tendency toward greater simplicity in organization; though this tendency is not so marked in 1896 as in some previous years. The total number of railway corporations, on June 30, 1896, was 1,985, and of this number 1,008 maintain operating accounts and render operating reports.

The equipment account of the railways of the United States is given as follows for the years ending on June 30, 1894-95-96:

	1894.	1895.	1896.
Locomotives.	35,492	35,690	35,950
Passenger cars.	33,018	33,112	33,003
Freight cars.	1,205,160	1,196,119	1,221,887
Company's service. . . .	39,891	41,330	42,750
Total cars in service.	1,278,078	1,270,561	1,297,640
Leased cars.	181,664	178,107	177,456
Fast freight service.	44,212	49,472	44,701

The detailed summaries given for 1896 show a decrease in the number of locomotives and cars assigned to passenger service, and an increase in the freight service. This change is the more significant as it was in the opposite direction in the previous year. An assignment of equipment per 100 miles of line gives the following general result: The railways of the United States employ 6 passenger, 11 freight and 3 switching locomotives, or 20 in all, for each hundred miles of line. For the same unit they use 713 cars, of which 18 are passenger, 672 are for freight and 23 are cars in the company service. The states of New York and Pennsylvania, however, show a record of 45 locomotives and 1,912 cars per 100 miles of line, and the New England States and those lying between the seaboard and Chicago also show a greater amount of equipment in proportion to mileage. The same table shows that 51,471 passengers have been carried, and 1,312,381 passenger-miles have been made per passenger locomotive; and 37,634 tons of freight have been carried and 4,684,210 ton-miles made per freight locomotive. The number of passenger cars per 1,000,000 passengers, in the year 1896, was 64, and the number of freight cars per 1,000,000 tons of freight carried was 1,595. In every case these figures indicate an improved economy in the use of railway equipment over the previous year.

The comparative equipment of locomotives and cars with train brakes and automatic couplers, stands as follows, for 1889-1896:

	1889.	1896.
Total equipment.	1,098,602	1,333,589
Fitted with train brakes.	128,159	448,85+
" " automatic couplers. . . .	80,510	545,583
Locomotives with train brakes.	. . . .	31,532
Cars " " "	. . . .	417,322
Locomotives with automatic couplers.	. . . .	8,635
Cars " " "	. . . .	536,948

During 1896, 1,209 freight locomotives were fitted with train brakes, leaving 2,430 yet to be fitted. Of passenger locomotives, 4,503, out of a total of 9,943, were fitted with automatic couplers; and 3,373 freight locomotives, out of 20,351, were so equipped. Of the 33,003 passenger cars in use on June 30, 1896, 590 were not fitted with train brakes, and only 379,058 freight cars, out of 1,221,887, were so fitted. Out of the total of passenger cars, 31,846 had automatic couplers, and these were on only 500,233 of the freight cars noted above. But the net gain in automatic couplers on the freight cars was 107,480 for the year.

The total number of railway employees was 826,620, in 1896; as compared with 785,034 in 1895, 779,608 in 1894, and 873,602 in 1893, the latter being the highest number of employees of railways on record. Assigned to a mileage basis the returns for 1896 show 454 men per 100 miles of line, as compared with 515 men in 1893. Of the men employed last year, 31,792 come under the head of general administration, 243,627 were engaged in maintenance of way and structures, 167,850 maintained equipment, 373,747 conducted transportation, and 9,609 were unclassified. Freight and passenger movement required an average of 205 men per 100 miles of line; maintainance of equipment, 92 men; maintenance of way and structures, 134 men, and administration, 18 men for the same unit. From other detailed tables given it appears that the aggregate amount paid in wages and salaries in the year was $468,824,531, or 60.65% of the total operating expenses of $772,989,044.

On June 30, 1896, the amount of railway capital was $10,566,865,771, or a capitalization per mile of line of $59,610. If current liabilities of $613,000,000 were included in railway capital, the capital per mile of line would be $63,068. In a more detailed summary the total railway capital for the year 1896 stands as follows:

Total common stock.	$4,256,570,577
Total preferred stock.	969,956,632
Total stock.	5,226,527,209
Stock per mile of line, average.	29,484
Per cent. of group capital.	49.46
Bonds.	4,517,872,063
Miscellaneous obligations.	457,735,531
Income bonds	314,425,977
Equipment trust obligations.	50,304,931
Total bonded indebtedness.	5,340,338,502
Bonds per mile of line, average.	30,126
Per cent. of group capital.	50.54

As compared with 1890, the aggregate value of stocks and bonds shows an increase from $9,437,343,420 to $10,566,865,771; but the average per mile of line is slightly reduced in apparent amount from $60,340, in 1890, to $59,610; as already shown, however, the addition of current liabilities to the capital account, as was done in previous reports, would show an actual increase in the average per mile of line, to $63,068, in 1896. The figures also indicate a change in railway financiering. Previous to June 30, 1895, the increase in railway capital was in the direction of a larger issue of bonds than of stock. This ratio was changed in the year ending June 30, 1895; as, out of an aggregate increase of $156,095,551 for that year, the increase in capital stock amounted to $127,182,997, with only $28,912,554 increase in bonded indebtedness. The report of the present year also shows an increase of stocks and a de-

crease of bonds. The statistician suggests that these facts are to be explained in the financial difficulties under which some of the roads have labored, and the tendency in reorganization to convert funded debt into stock without cancelling original stock.

The hard times of the last few years are reflected in the further statement that stocks aggregating $3,667,503,194 paid no dividends during the year covered by the report. This is 70.17% of all outstanding stock, and is the largest total to be found in the nine years of the Commission's existence. Of the funded debt, $860,559,442, or 16.26% of the total funded debt, paid no interest in the year, a slight change from the previous year. The general summaries show a steady decline in dividend-paying stocks since 1892; but, while in the previous three years the decline was sharp and decisive, the present report indicates an arrest of this downward tendency. The amount actually paid in dividends during the year was $87,603,371, or an average of 5.62% on dividend-paying stock.

The number of passengers carried in the year reported upon was 511,772,737, or an increase of 4,351,375 over the previous year of 1895. But while all the items show a slight increase in passenger traffic, they do not indicate the recovery of even normal traffic. In the year under review, however, 765,891,385 tons of freight were carried on the railways, a larger tonnage than for any other year in the history of American railways. The increase for 1896 was 69,130,214 tons, and this, added to the increase of 58,574,618 tons, in 1895 over 1894, show that the railways have recovered the freight traffic lost in 1893-94. There is also a betterment in the operating conditions, as shown by the increased average number of passengers per train, the length of the average journey per passenger, and the average tonnage and average haul of freight.

Under the head of earnings and expenses we find that the total earnings from operation, in the year ending June 30, 1896, were $1,150,169,376, an increase of $74,797,914 over the previous year. The total expenses for 1896 were $772,989,044, an increase of $47,268,629 over 1895; much of which was rendered necessary by neglected repairs in previous years. The actual increase in income from operation, in 1896, was $27,529,285, and with income from other sources added, the final net income showed an increase of $33,515,667 over the previous year.

In the year in question $160,344,950 was expended in maintenance of way and structures, and $133,381,998 in maintenance of equipment; the expenses of conducting transportation were $442,217,582, and for general expenses, $36,083,285. With $961,229 of unclassified expenses added, the total of operating expenses is $772,989,044; as compared with $725,720,415 in 1895.

The following interesting comparative summary of results, for 1890 and 1896, is taken from one giving each year in detail:

	1890.	1896.
Revenue per passenger, cts.	2.137	2.019
" " ton-mile, freight, cts.	.941	.806
" " train-mile, pas. trains, cts	.108.041	98.591
" " " fgt. train, cts.	.165.434	163.337
" " " all trains, cts.	.144.231	139.567
Avg. cost running all trains 1 mile, cts	96.006	93.838
Per cent. operating exp. to oper. income	65.80	67.20
Passenger earnings per mile of line. . ..	....	$1,316.18
Freight " " " " "	....	4,343.83

Under the head of railway accidents we find tables stating that in the fiscal year 1,861 employees were killed, and 29,969 were injured; or an increase of 50 killed and 4,273 injured, as compared with previous year. The number of passengers killed was 181, and 2,873 were injured; an increase of 11 killed and 498 injured over 1895. This showing, while better than the average for the years 1888-1896, does not show that the railways were operated with as high a degree of safety to the employees and passengers as in the previous year. Among the employees, 229 were killed and 8,457 injured in coupling and uncoupling cars; and 472 were killed and 3,898 injured in falling from trains and engines. The number employed for each man killed was 444, and 1 in 28 employees were injured; and when this ratio is applied to trainmen only, 1 in 152 was killed and 1 in 10 injured. Among passengers, 1 in 178,132 carried was injured; but the number of passengers carried one mile for one passenger killed was 72,093,963, and for each passenger injured, 4,541,945.

A NEW YEAR POEM.

Many of the older readers of Engineering News may remember that in former years we have at times given space in our issue published at the midwinter holiday season to some articles of a less severely technical nature than those to which our columns are usually devoted. We are reminded of this by the receipt of a little blue-print pamphlet, the front cover of which bears a sketch that appeared in our issue of Jan. 7, 1888, representing a very chilly surveyor squinting through an icicle-hung transit.

The pamphlet in question contains a dissertation in verse upon "The Engineer," a topic which is of considerable interest to most of our readers; and we reprint some of the stanzas here, with acknowledgments to Mr. Chester T. Dike, City Engineer of Mason City, Ia., to whose courtesy we are indebted for the pamphlet.

THE ENGINEER.

Who comes with Faber sharpened keen,
With profile long and sober mien,
With transit, level, book and tape,
And glittering axe to swat the stake?
The Engineer.

Who sets the level, bends his spine,
Squints through the glass along the line,
Swings both his arms at rapid rate,
Yells, "Hold that bloomin' rod up straight?"
The Engineer.

Who raves and snorts like one insane,
Jumps in the air and claws his mane,
Whene'er he sees a scraper take
A whack at his most cherished stake?
The Engineer.

Who swears he'll charge "an even ten"
For stakes destroyed by mules or men
While on all fours he tries in vain
To find the vanished stake again?
The Engineer.

Who saws the air with maddened rage,
And turns with haste the figured page,
And then, with patience out of joint,
Ties in another "reference point?"
The Engineer.

Who calls it "your unrivalled gall,"
Whene'er you kick for "overhaul,"
And gives your spine the frigid chill
Whene'er you spring an "extra bill?"
The Engineer.

Who deals with figures quite profuse;
Then tells you solid rock is loose;
That hard-pan's nothing more than loam,
While gumbo's lighter than sea foam?
The Engineer.

Who, after all, commands our praise
(In spite of his peculiar ways),
While others harvest all the gains
That spring from his prolific brains?
The Engineer.

THE POLLUTION OF THE POTOMAC RIVER.

For years past the reports of the Commissioners of the District of Columbia have had more or less to say regarding the character of the water supply of the national capital. The water is undeniably muddy or turbid at times, besides which there has been much talk of sewage pollution from towns and cities above the intake. Settling basins have been recommended as necessary adjuncts to the supply if it is to be furnished with a uniformly pleasant appearance, and filters have often been spoken of as desirable if the supply is to be safe for domestic purposes.

Those especially interested in the Potomac River, or in the water supply of Washington and other cities in the drainage area of that river, will be glad to know that two papers regarding its pollution were read before the National Geographic Society, at Washington, on Nov. 19. One of these was by Mr. A. A. Davis, Assoc. M. Am. Soc. C. E., Hydrographer U. S. Geological Survey, Washington, D. C., and described the physical characteristics of the stream, including its drainage area, volume at various points and the sources of pollution. The other took up the bacterial side of the subject, and was by Mr. E. K. Sprague, Passed Assistant Surgeon, U. S. Marine Hospital Service, Washington, D. C.

Mr. Davis states that the drainage area of the Potomac lies in the states of Pennsylvania, Maryland, West Virginia and Virginia. The stream and its tributaries are subject to sudden floods and the dry weather flow is very small, owing to the fact that the drainage area contains almost no lakes, marshes or broad valleys. The only falls of magnitude are near Washington, where the stream finally breaks through the cretaceous rocks, at what is known on the Atlantic Coast streams as the "fall line." Here there is a total drop of 90 ft. within a short distance, known as the Great Falls. The water supply of Washington is taken from the river just above the falls, there being a masonry dam of 2,877 ft. long at the point of intake, and most of the city being served by gravity.

The water from the highlands is pure and clear, but on reaching the lowlands it takes up washings from rich soils and cultivated fields, which impart turbidity and a yellow color to the stream. Besides this, mining and manufacturing wastes reach the river and its tributaries, and there is sewage pollution at many points, though most of the towns are comparatively small.

The minimum flow of the Potomac River is taken as 1,063 sec.-ft., as measured by Mr. Wm. R. Hutton in 1856. It is thought that the flow fell to about that amount during the long dry spell this last fall. At the same time the water taken from the river to supply Washington was from 75 to 90 sec.-ft., or 7 to 9% of the total flow. The flood discharge of the stream at this point is believed to be 40,000 to 50,000 sec.-ft., or even more.

The detailed accounts of various sources of pollution given by Mr. Davis we must pass over. He does not attempt to say to what extent this pollution endangers the water supply of Washington. He suggests that steps should be taken, through national and state legislation, to prevent pollution and that all city water supplies from surface sources suspected of pollution should be purified.

Dr. Sprague states in his paper that recent examinations of Potomac water made at the Hygienic Laboratory of the Marine Hospital Service, since July, 1897, show a variation of from 33 to 4,600 bacteria per cu. cm., and that since Aug. 1, intestinal bacteria have been found in every sample but one. In 55 samples collected by representatives of the U. S. Geological Survey from the river and its tributaries at points above Washington, at or near important towns, Dr. Sprague states that intestinal bacteria were found in over 90% of the samples.

By way of caution we would state that some of our best investigators of water supplies from the bacterial standpoint lay but little stress upon mere counts of the number of bacteria in natural water, and perhaps even less upon attempts to differentiate species, although believing fully in the value of bacterial determinations in studying the efficiency of filter plants. It is true, however, as Dr. Sprague states, that with a large number of bacteria in water there is greater likelihood that some dangerous species will be present.

What we consider to be the most significant thing in Dr. Sprague's paper, as indicating that Washington has a polluted water supply, is his statement that the typhoid fever death rate in the District of Columbia has risen from 33 per 100,000 inhabitants in 1883 to 83 in 1896, placing Washington high in the list of cities in the United States suffering with excessive typhoid. This, coupled with Mr. Davis's descriptions of actual sources of sewage pollution, goes farther than any bacterial analyses possible in the present state of the art, to throw suspicion on the water supply of Washington.

In discussing remedies for the pollution of the Potomac, Dr. Sprague gives as his belief that sanitary control of so large a drainage area as the Potomac, lying in four states, is impracticable as a safeguard against water-borne diseases; that placing reliance upon boiling the water is leaning on a broken reed, since many will not take the trouble to do this, and the water is insipid or not always at hand for use when this treatment is given it; that the purchase of pure water for drinking purposes is out of the question for large numbers of the population, and is perhaps to be considered as an imposition upon those who pay a water tax for a city supply; and, finally, that filtration at a central station is the only practicable and by far the safest measure to adopt to ensure a pure water supply to the people of Washington.